NOVEMBER 1952

Journal

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AMERICAN WATER WORKS ASSOCIATION

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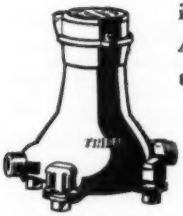

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Journal

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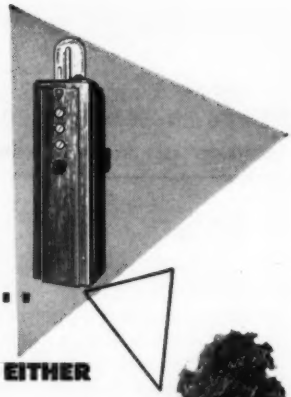

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 44 • NOVEMBER 1952 • NO. 11

Standard Allowances for Water Hammer

Panel Discussion

A panel discussion presented on May 6, 1952, at the Annual Conference, Kansas City, Mo., by S. Logan Kerr, Cons. Engr., S. Logan Kerr and Co., Inc., Philadelphia; Frank A. Marston, Partner, Metcalf & Eddy, Engrs., Boston, Mass.; Thomas F. Wolfe, Engr., Cast Iron Pipe Research Assn., Chicago; Walter H. Cates, Mgr., Hydraulics Div., Consolidated Western Steel Corp., Los Angeles; Arthur J. Maahs, Chief Engr., Transite Pipe Dept., Johns-Manville Sales Corp., New York; and Hugh F. Kennison, Chief Engr., Lock Joint Pipe Co., East Orange, N.J.

Introduction—*S. Logan Kerr*

MUCH attention has been devoted to water hammer in recent years by the American Water Works Assn., the American Society of Mechanical Engrs., and the American Society of Civil Engrs. Numerous articles have been published setting forth the theory of water hammer, its application to many problems, and the means for analyzing various types of surge action. There has been much discussion, particularly in AWWA committee proceedings, of the preparation of standard specifications for different types of pipe. When the problem of water hammer is discussed, divergent opinions arise on the merits of setting up standard allowances for water hammer of the type that have been used for cast-iron pipe (1).

This panel discussion has been organized to guide the committees in their work and to determine whether or not the existing standard allowances for cast-iron pipe are satisfactory or whether they should be revised. Consultants, manufacturers, and users of water works pipe present their views in this panel. The author presents an outline of the factors involved in standard allowances for water hammer.

Allowances for Cast-Iron Pipe

The current standard allowances for cast-iron pipe (1) seem to stem from work done in the early 1890's and are generally attributed to Dexter Brackett, then engineer of the Boston water works. The recommended values vary from 120 psi for 4-in. pipe to 70 psi

for 60-in. pipe. There is no adjustment in the allowances for variations in thickness for any given diameter, but merely a flat allowance above the normal working pressures.

In the 1890's water was supplied to distribution systems through gravity mains leading from a reservoir into which the water flowed from natural sources or was pumped by steam engines or hydraulic turbines. The velocities employed were low, and the type of pipe available was limited largely to cast iron, usually having bell-and-spigot joints. It seems desirable, under present-day conditions, to reexamine these allowances to see if they are adequate or if changes should be made.

Many factors which were not present 60 years ago now exist. Much of the water supply, particularly in this country, is handled by motor-driven centrifugal pumps, which were relatively unknown in the 1890's. Automatic stop, check, and throttling valves were not used so widely as they are today. Valve closures measured in seconds were practically unknown. Many new types of pipe are now available that were unknown or infrequently used in water works systems then. The velocity of flow in pipelines and distribution systems is frequently greater now than it was at the turn of the century. In larger systems, factors of safety have been reduced for economic reasons, and the methods of jointing pipe have changed materially.

Under these conditions, it is questionable whether standard allowances for water hammer should be applied universally to all types of installations. Nor can it be said that such allowances will provide full security in all circumstances.

Criterion for Allowances

In the original specifications, only a single type of pipe was considered, but under present conditions some new criterion is necessary, provided, of course, that standard allowances are still desirable. In attempting to set up a criterion, several questions arise:

1. Should the allowances be the same for all types of pipe, or should they be adjusted for size, material, and thickness?
2. Should allowances be applied universally, or should they be limited to certain types of service, such as distribution lines alone?
3. Should these allowances be applicable to internal station piping, external station piping, or filter plant piping?
4. Should pumping mains to reservoirs or pumping mains to distribution systems have separate classifications from gravity lines or long transmission mains?
5. Should other factors calling for allowances on top of allowances be included where automatic control valves, check valves, and other quick-acting devices are present?

Normal Working Pressures

In reviewing the desirability of standard allowances for water hammer, some attention should be devoted to the method by which normal working pressures are established. Are they based upon an assumed desirable delivered pressure in the distribution system? Are they fixed by the available pressures from reservoirs? Or are they based upon elevated storage or on direct pumping into the mains?

In many installations, it is customary to adjust the thickness of the pipe on long transmission mains as a function of the hydraulic gradient. When

the profile of the line changes considerably, the pipe is heavier at the bottom of the hill than at the top, and the factor of safety under water hammer conditions is therefore greatly reduced at these high points. Under such conditions, how can standard allowances for water hammer be applied to assure the safety of the pipeline and not merely to provide false security? If water hammer allowances are provided on top of the hydraulic gradient, would they be ample to cover the surge gradient under many operating conditions, including power failures at pumping stations, parting and rejoining of water columns, and various other factors?

Economic Considerations

Another important consideration is the economic factor relating to the selection of pipe in any installation. Some attention should be given to the effect of standard allowances for water hammer upon the cost of an installation to determine whether or not such factors would increase or decrease the costs. Probably no general rule can be set forth which would provide the ideal solution for all installations.

Conclusion

It seems worth while to inquire into the merit of standard allowances. Are they desirable? Do they have a real place in water works engineering? Do they act as a substitute for good engineering or do they supplement good engineering? The discussions which follow consider these factors and attempt to offer an improved basis for the work of specification committees.

Reference

1. American Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe—ASA A21.1. Am. Water Works Assn., New York (1939); Jour. AWWA, **31**: *following* p. 2194 (Dec. 1939).

Consulting Engineer's Viewpoint—*Frank A. Marston*

An adequate theory of water hammer applicable to simple pipes, pipes of varying diameter, and branching pipes is available to the engineer today. Its application to piping networks is not yet practicable. The application of the water hammer theory in any given installation is still the province of the specialist and will doubtless remain so for some time.

Inasmuch as the effect of water hammer in the ordinary water distribution system consisting of a piping network is not subject to computation, it is believed proper to make some allowance for water hammer in the manufacture of the pipe. Equivalent allowances should be made for all types of pipe, giving consideration to the various materials and their resistance to shock.

The allowances for water hammer that are included in the design of the pipe should be specifically stated in the standard specifications in order to avoid the pyramiding of allowances in those installations for which water hammer pressures are computed. Water hammer can and should be considered in the design of pumping station piping, force mains, and long supply mains, and suitable means should be provided to reduce its effect to the minimum that is practicable or economical.

Pumping Stations

The present practice of using higher pump discharge velocities and electric motor-driven centrifugal pumps, which are subject to occasional stoppage be-

cause of power failure, has made water hammer problems increasingly serious.

It is believed that in recent years increased attention has been given to the use of water hammer preventive equipment in the design of pumping stations. Such equipment includes special check valves, pressure relief valves, and surge suppressors. These devices, if properly designed, will materially reduce the effect of water hammer.

Existing Standard Allowances

The existing standard allowances for water hammer in the design of cast-iron pipe are given in Sec. 1–7 of the American Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe (1). This manual states: "Experiments on water hammer under the various usual conditions in which water pipe are used are few and Committee A21 has been unable from its inquiries to suggest improvements over the assumptions of water hammer made by the late Dexter Brackett. . . . *Each designer of a pipeline should consider whether the conditions in his case may need a more liberal water hammer allowance.*"

These allowances for water hammer vary from 120 psi for pipes 4 to 10 in. in diameter to 70 psi for pipes 42 to 60 in. in diameter and are probably adequate for general conditions in a municipal water system consisting of a piping network. On the other hand, for a supply main or force mains subject to sudden changes in flow velocity or to possible reversal of flow with resultant distinctive water hammer pressures, the allowances are entirely inadequate.

Under such special conditions, the designer, recognizing that sudden changes in velocity can create water hammer pressures several times the static water pressure, will often use pipe of a heavier class than would be justified if consideration were given only to the static pressure on the pipe. On two occasions, for example, the author's firm has used Class 250 bell-and-spigot pipe for reinforcing systems designed primarily for fire protection service although the static pressure was 130 psi.

If standard allowances are to be used in the design of pipe, they obviously cannot be based on the velocity of flow within the pipe, but presumably would be varied with pipe diameter and thickness. There may be some justification for higher allowances in the smaller pipes, such as 6–12 in., because these are the sizes generally used in the distribution systems which are not subject to water hammer analyses.

The author feels that the entire subject of allowances for water hammer in the design of pipes should be reviewed in the light of present-day knowledge and practice.

Reference

1. American Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe—ASA A21.1. Am. Water Works Assn., New York (1939); Jour. AWWA, **31**: *following* p. 2194 (Dec. 1939).

Cast-Iron Pipe—*Thomas F. Wolfe*

Although the water hammer values which ASA Committee A21 uses for the design of cast-iron pipe were established in 1886, modern pipe designed on the basis of these values performs satisfactorily. Engineers are probably concerned about water hammer because the water hammer formulas in

ordinary use indicate the possibility of surges greatly in excess of those allowed in the pipe design formula. The author seriously doubts that these formulas are applicable to the ordinary water distribution system. Except for supply lines, there are no long, isolated lines in the ordinary system. The frequent intervals at which branches and service pipes are taken off mains undoubtedly have a marked preventive effect on the build-up of high pressures resulting from surges.

As the formulas do not apply to water works distribution systems, experience is the only guide. If excessive pressures occurred, undoubtedly customers would complain about the noises coming from the plumbing systems. It is also probable that those parts of the system having less strength than cast-iron pipe would fail—for example, lead services, corroded plumbing, and hot-water heaters. That these failures occur only infrequently would seem to indicate that extremely high pressures are rare.

Undoubtedly water hammer occurs to some extent in every water works system. From the standpoint of pipe design, the important questions are: What is the cause of water hammer? What is its magnitude? What corrective measures, if any, can be applied to mitigate or eliminate it? The author feels that these questions indicate the necessity for subdividing a water system into supply and distribution categories.

Supply Lines

Water hammer in supply lines stems almost entirely from pump or valve operation. A power failure in an electrically driven pump when the line is working at its maximum capacity would probably result in the severest water hammer. It is conceivable that, without controls, reversal of flow or partial vacuum might occur, with a resulting shock in excess of that provided for by the present specification. Control devices are available, however, to reduce the shock to such a point that excessive pressures cannot occur. These devices have been used successfully in many long supply lines throughout the country.

Distribution Systems

The principal causes for surges in distribution systems include:

1. Fast operation of valves
2. "Jumping" or "slamming" caused by operating fire hydrants with faulty or worn mechanisms
3. Large services drawing water at a high rate intermittently
4. Fire pumps connected directly to the system
5. Taking railway locomotive supply directly from the mains
6. Certain types of airfield gasoline-handling systems that use water to displace gasoline.

There are probably many other similar causes. An examination of each of the above causes, however, will reveal remedies for mitigating water hammer. In general, the ordinary type of valve used in distribution work does not lend itself to fast operation. Proper training of personnel will alleviate the difficulty with valves which can be closed too quickly. If fire hydrants were properly maintained and their use limited to authorized personnel, the slamming of the valve during the last part of the closure, which results in water hammer, would not occur. Large customers who intermittently draw water at a high rate should be required to revise their system so that water is drawn continuously at a lower rate. Air chambers, or, sometimes, ground level or elevated storage within the

premises, would alleviate water hammer caused by fire pumps connected directly to the distribution system. Railway locomotives should be prohibited from making direct connection to the distribution system, and airfields should be required to repump water from a reservoir supplied from the city system.

Cast-Iron Pipe Design

Even though precautions are taken, water hammer will still occur and, therefore, provision should be made for water hammer of some magnitude. Some of the details of the new method of design for cast-iron pipe developed by Committee A21 are of interest. By this method, the thickness of a pipe must depend upon the pressure under which the pipe will operate, a definite allowance for water hammer, the load imposed by backfill, and stresses caused by street traffic. Maximum stresses from street traffic are calculated on the basis of two trucks, each with a wheel load of 9,000 lb, passing one another over the pipe. Inasmuch as the passing of two trucks over a pipe is instantaneous, and water hammer at any point in the line is instantaneous, the committee decided to use either water hammer or truck load, whichever gave the greater value, in calculating the wall thickness. Under certain trench conditions, the governing factor is truck load alone—for example, a 6-in. pipe under 5 ft of cover, operating at 50 psi working pressure, has a calculated thickness of 0.28 in., a thickness that is determined by the truck's greatest load. On the other hand, if the same pipe were to operate at 150 psi working pressure, the total internal pressure including water hammer is used rather than truck load, as it gives a greater wall thickness. When 36-in. pipe under 5 ft of cover with working pressures up to 150 psi is used, the truck load is the controlling factor; water hammer enters the formula for pressures above 150 lb. The thickness of the same 36-in. pipe, when the cover is 8 ft or more, however, is controlled by water hammer rather than by truck load. The effect of the truck load diminishes as the depth of trench load increases. There will be some difference in these thicknesses if different values are used for water hammer. The values used at present are justified because pipe designed using present values for water hammer has worked satisfactorily for many years.

The breaks that occur in small-diameter pipe are usually caused by beam action and not by the effects of pressure. Failures in large-diameter pipe are usually due to ring stresses caused by the concentration of trench loads resulting from poor foundation or foundation disturbance.

Most cast-iron pipe sold is used for pressures of 150 psi or less, yet each length of pipe 12 in. and less in diameter is tested at 500 psi pressure at the foundry and larger pipe is tested at 400–500 psi, depending on the diameter and thickness. A 6-in. Class 22 pipe (0.38 in. thick), the minimum covered by Committee A21 specifications, would actually fail from bursting alone at a pressure of approximately 2,500 psi; a 12-in. Class 22 pipe would fail at approximately 1,500 psi; a 24-in. at 1,000 psi; and a 36-in. at 900 psi.

Satisfactory Water Hammer Values

The values for water hammer adopted many years ago and now used not only in specifications prepared by Committee A21, but also in the American Society of Mechanical Engrs. Code for Pressure Piping, are satisfactory because:

1. Modern control devices can mitigate water hammer in supply lines.
2. Proper control over use by customers can lessen the opportunities for water hammer in distribution systems.
3. Care and operation of valves and fire hydrants and proper maintenance of these parts of the system will reduce the opportunities for water hammer to occur.
4. The overall factor of safety of 2.5 used in the pipe design provides for the occasional surge in excess of the amount for which the pipe is designed.
5. Pipe failures are rarely, if ever, caused by internal pressures alone, indicating that the present allowance is high enough.
6. Lowering the water hammer allowance would not materially reduce the thickness of the pipe and would represent no financial advantage to the pipe user.

Steel Pipe—*Walter H. Cates*

This discussion is confined to welded steel pipe as manufactured under standard specifications AWWA C201 (formerly 7A.3) and C202 (formerly 7A.4), and operating under normal water works service. The quality of steel plate is based on a minimum yield point of 27,000 psi, and the design stress for static internal pressure is assumed to be 15,000 psi, or 55 per cent of the minimum yield point value. Furthermore, the maximum fiber stress value permitted in the above specifications for hydrostatic test pressure is 22,000 psi, or 80 per cent of the yield point value. From a practical viewpoint, the maximum water hammer stress also may safely reach 22,000 psi (147 per cent of 15,000) before special allowance is necessary.

Determination of Allowance

The formulas for water hammer take into account the elasticity of the steel pipe wall and of the water contained in the pipe, and the velocity of the pressure wave along the pipe. On these assumptions, to determine whether any allowance for water hammer in steel pipe should be made for any specific installation, the designing engineer should calculate the pressure resulting from water hammer in excess of static pressure for instantaneous closure. If this value is less than 47 per cent of the safe working pressure of the pipe (based on a steel plate design stress of 15,000 psi), it is not necessary to make an allowance for water hammer.

If the pressure resulting from water hammer in excess of static pressure is greater than 47 per cent of the safe working pressure, the fiber stress based on the combined pressures of water hammer and the actual static working pressure must be computed. If the computed stress exceeds 22,000 psi, consideration must be given to using a quality of steel plate having a higher yield point than 27,000 psi (30,000 or 33,000 psi). Then 80 per cent of the higher yield point value should be compared with the total calculated stress value. If the stress value, on this basis, is less than 80 per cent of the yield point, no allowance is needed. Otherwise, the plate thickness should be increased until it falls within the safe limit of stress, or else regulating valves, slow-closing valves, air chambers, surge tanks, or other surge-suppressing devices should be installed. Slow-closing valves should always be used in any water piping system as these valves minimize the effect of

water hammer appreciably and automatically.

Steel Pipe Plate Thickness

Most engineers who design major water works systems do not make allowance for water hammer in steel pipe because the plate thickness generally adopted to meet external loads is greater than that required for static internal pressure alone. Mechanical devices for water hammer relief are installed to control any possible excess pressure, particularly on pumping lines. Also, steel pipe possesses high strength and ductility and, thus, can readily resist ordinary water hammer pressures without danger.

It can generally be concluded, therefore, that for the average water works system using steel pipe installations, no standard allowance for water hammer is needed. Each installation should be investigated for maximum possible pressure conditions, however, and, if found to be within the limits outlined herein, no further consideration is required. Otherwise, design factors, as suggested, must be adopted to reduce effectively excess dynamic pressure.

The "Symposium on Water Hammer" (1) is one of the best presentations of this subject and the author recommends it as well as other studies (2–15) to engineers who are working on the problem of water hammer.

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Asbestos-Cement Pressure Pipe—*Arthur J. Maahs*

The question has been asked: Are standard water hammer allowances needed for asbestos-cement pipe? The author's experience indicates that no specific allowance is necessary for pipe used in distribution systems if the pipe provides an adequate safety factor for all the unknown variables, including water hammer, that may be encountered in service either singly or in combination.

Strength Requirements

The author's company has established strength requirements and installation procedures which, together

with the inherent advantages of asbestos cement, have resulted in excellent performance. These strength requirements have been based largely on twenty years' experience in the manufacture and installation of asbestos-cement pressure pipe for the water works industry. During this period, 100 million feet of asbestos-cement pipe have been installed and are now in service in the United States.

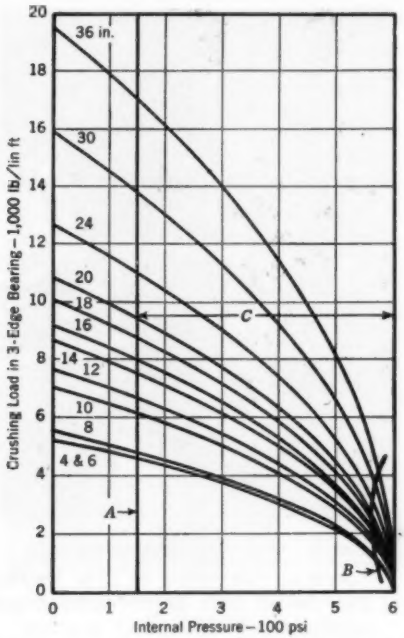

Fig. 1. Load Pressure Curves for Class 150 Asbestos-Cement Pipe

Line A *indicates that portion of the hydrostatic strength utilized for the recommended working pressure. Curve* B *indicates that portion of the hydrostatic strength and crushing strength utilized for the fill load, surface load, and impact resulting when the pipe is installed in accordance with the typical conditions illustrated in Fig. 2. Line* C *indicates the available hydrostatic strength for field test pressures, water hammer, fill loads, surface loads, impact, and corrosion.*

It is reasonable to assume that this extensive and satisfactory usage of asbestos-cement pipe throughout the United States would yield information that covers water hammer conditions as they generally exist in the water works industry. The objective in establishing strength requirements for asbestos-cement pipe has been to insure its satisfactory performance under normal conditions of working pressure, field test pressures, water hammer, backfill, surface loads, impact, and internal and external corrosion encountered in distribution systems.

That exceptional conditions of pipeline operation can develop unusually high internal pressures has been recognized in establishing the strength requirements, but experience has shown that such conditions are rarely encountered in systems designed, installed, and operated in reasonable accordance with good practice. It was also appreciated that there could be exceptional conditions of backfill, surface loads, and impact that would develop unusually high crushing stresses in the pipe wall, but, again, experience has shown that such extreme conditions are generally recognized and bedding conditions are provided to keep these stresses within acceptable limits.

Hydrostatic Tests

In establishing strength requirements, it was known that normal water pressure, water hammer, and trench loads developed combinations of tensile and compressive stress in the pipe, but it was not known to what degree or to what extent these stresses were cumulative in distribution systems. Consequently, the author's company adopted a policy of testing each length of pipe hydrostatically to a known bursting

strength. This test assured enough strength, in handling internal pressures, external loads, and all other variables, to provide a satisfactory degree of performance.

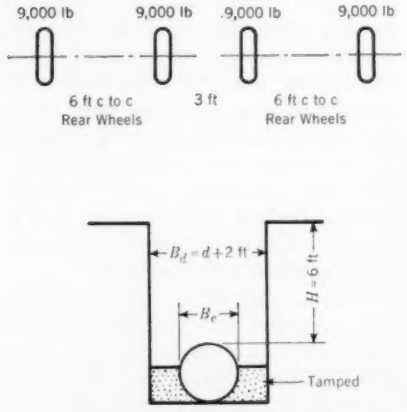

Fig. 2. Typical Fill Load, Surface Load, and Impact Conditions

The upper figure represents the surface load that results from the rear wheels of two passing trucks. The lower figure represents a tamped flat-bottom trench. The weight of the fill is 120 lb per cu ft. B_c *represents the OD of the pipe,* B_d *the width of the trench, and* d *the internal diameter of the conduit.* $Ku = 0.1924$ *and* $Ku' = 0.130$ *where* K *is the ratio of active lateral pressure to vertical pressure,* u *is the coefficient of internal friction of the fill material, and* u′ *is the coefficient of sliding friction between the fill materials and the sides of the trench.* $r_s p = 0.75$ *for all sizes of pipe where* r_s *is the settlement ratio and* p *is the projection ratio.*

In the early days of manufacture in this country, hydrostatic test pressure was established at two times the working pressure recommended for the pipe, the same practice as that used in Europe, where the pipe was first manufactured nearly half a century ago. Shortly thereafter, recognizing the higher standards in effect in the United States, the manufacturing procedures were improved to provide a pipe capable of withstanding a hydrostatic test pressure of four times the working pressure recommended for the pipe. Performance and acceptance then increased rapidly, indicating that adequate bursting strength was being made available.

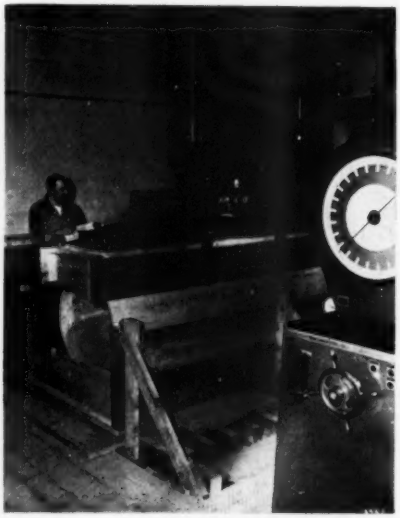

Fig. 3. 300,000-lb Testing Machine

The load is transmitted to 13-ft lengths of pipe which have been bedded under conditions encountered in practice.

Strength Standards

Not all strength standards for asbestos-cement pipe are at the level established by the author's company. In 1940 a federal specification for asbestos-cement pipe was issued which called for a hydrostatic test of each length of pipe to 2.5 times the recommended working pressure. In addition, the specification called for a

hydrostatic test to destruction on representative samples, but did not establish an ultimate strength level.

Currently the AWWA and ASTM specification committees for asbestos-cement pipe are proposing a hydrostatic test of each pipe to 3.5 times the recommended working pressure. The AWWA specification committee is considering an additional hydrostatic test on one of each 300 lengths to 4 times the recommended working pressure in order to provide a minimum ultimate strength level of the pipe. A requirement for a minimum crushing strength for trench loads is also being considered.

Fig. 4. Bedding Pipe Before Load is Applied

If the law of pipe behavior under simultaneous external loading and internal pressure, as developed by W. J. Schlick (1) of Iowa State College, is applied, and if the proposed strength requirements are used, the available strength for the unknown variables plus a safety factor becomes apparent immediately, as shown in Fig. 1. The load pressure curves for each size of Class 150 asbestos-cement pipe,* the manufacturer's standard recommendation for distribution piping, are plotted in Fig. 1. The ordinates represent exterior loads in pounds per linear foot of pipe under three-edge bearing conditions and the abscissas internal pressures. Each extreme of the curves is the minimum proposed strength requirement. The vertical line (A) indicates that portion of the hydrostatic strength utilized for the recommended working pressure. The vertical curve (B) indicates that portion of the hydrostatic strength and crushing strength utilized for the fill load, surface load, and impact resulting when the pipe is installed in accordance with the typical conditions illustrated in Fig. 2.

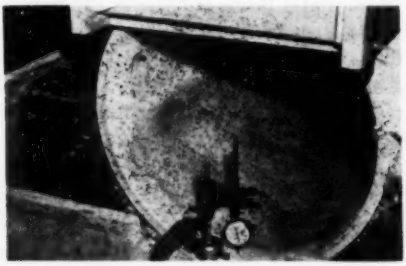

Fig. 5. Micrometer Dial Indicators Used to Record Pipe Settlement

The load wire leads to the SR-4 strain gages that are used to record strain in various parts of the pipe while under load.

Supporting Strength

The author's company is currently conducting tests to establish the supporting strength of asbestos-cement pipe bedded in trenches in accordance with actual practices. These tests supplement available data. Figure 3

* Transite, a product of Johns-Manville Corp., New York, was used.

shows the 300,000-lb testing machine * and the method of transmitting the load to 13-ft lengths of pipe bedded under conditions encountered in practice. Figure 4 shows the bedding of pipe before the load is applied. Figure 5 shows the Ames dial used to indicate settlement of the pipe into the bedding material and the load wires to the SR-4 strain gages † used to record strain in various parts of the pipe while under load.

Conclusion

The load-pressure curves (Fig. 1) show that a large portion of the hydrostatic strength is available for variables that may be encountered in service. This hydrostatic strength has proved to be adequate. It is felt that to break down this proved strength into a specific allowance for each operating variable and to indicate the combinations in which the allowances should be used is an unnecessary refinement, as a satisfactory overall strength requirement has been established for piping used in normal distribution systems.

In long transmission lines or in any piping system having unusual features, each variable should be considered individually, and pipe having adequate hydrostatic strength should be selected. Experience shows that, for these piping systems, engineers do analyze these conditions and select a class of pipe that will assure satisfactory performance and result in economical operation. The author feels that no specific water hammer allowance is necessary for asbestos-cement pipe having the hydrostatic strength described herein or being considered for inclusion in the proposed AWWA specification for asbestos-cement pipe.

* A product of the Baldwin Locomotive Works, Southwork Div., Philadelphia, was used.

† A product of the Baldwin-Lima Hamilton Corp., Philadelphia, was used.

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Concrete Pressure Pipe—*Hugh F. Kennison*

In discussing the question of the necessity for standard allowances for water hammer in concrete pressure pipe, three basic factors should be considered:

1. What is water hammer?
2. What means will be provided to prevent or reduce water hammer?
3. What inherent properties of reinforced concrete pressure pipe are available to withstand water hammer safely?

Definition

"Water hammer" is the term used to describe pressure fluctuation in full-flowing conduits caused by changes in velocity of the water being transported. Cyclical changes of kinetic energy to potential energy and back to kinetic energy occur. The trend to greater use of electrically driven pumps, with the ever-present possibility of power failures and abrupt pump stoppage, makes the study of water hammer increasingly important. During the past quarter of a century much theoretical and practical application of water hammer control has been established. The elastic-wave theory and its more recent graphical method of solution have done much to simplify the calculation of the effect.

Reduction of Water Hammer

There is no general solution for reducing water hammer in a specific pipeline. Positive controls can usually be applied only when the problem and its many ramifications are fully understood. In some pipelines, surge pressures can be reduced to negligible amounts simply by controlling the rate of change in velocity of the water during shutdown. This closing time is a function of the length of the line and the velocity of the surge wave in the conduit. Aside from abrupt closing time—that is, less than $\frac{2L}{a}$ seconds, L being the length of line in feet and a the velocity of the surge waves in feet per second—the maximum water hammer is proportional to the maximum instantaneous rate of change in water velocity. Thus, when the gate valves are operated manually, the minimum closing time that will create a specified maximum water hammer will be that obtained by a continuous but constantly slower operation of the hand wheel, thereby producing a constant rate of change of velocity, within practical limits.

Other pipelines, because of a high point in the profile between the source of supply and the discharge, may produce a downsurge pressure which causes a break in the water column. The water hammer created by the sudden rejoining of the water column can be particularly severe. Every effort should be made to limit the magnitude of the downsurge pressure. It may be possible to relocate or lower the pipeline to eliminate or reduce the high point in the profile. Automatic quick-opening, slow-closing air valves are available for such a condition. When located at the point of anticipated subatmospheric pressure, these valves temporarily supply an air cushion which greatly reduces the magnitude of the subsequent water hammer. Two or more small valves would be more reliable and, therefore, preferred to one large valve of equal capacity for limiting downsurge pressures.

No one intentionally shuts down a major pumping line by abruptly stopping the pumps, and yet, for design purposes, such a condition must be anticipated, to allow for power failure. Among other precautions, surge suppressors can be installed adjacent to the pumps. These units should be designed to operate on the immediate pressure drop in the pipeline so that they will be open when the low pressure wave returns $\frac{2L}{a}$ seconds later. When the wave is reflected at the stalled pumps, the increasing pressure will cause the water to be discharged through the surge suppressor, thereby preventing the creation of abnormal pressures.

The water hammer incidents mentioned may be oversimplified. In most installations, many different conditions can cause water hammer more or less simultaneously, but if each condition is understood and analyzed, definite preventive measures can be taken. No one can help being amazed at the accuracy with which complicated water hammer problems can be solved by those specializing in the field.

Inherent Properties

Three basic types of reinforced concrete pipe are used extensively today for pressure pipelines—reinforced concrete cylinder pipe, prestressed concrete cylinder pipe, and reinforced concrete pressure pipe. These types are described in specifications AWWA C300, C301, and C302, respectively. Depending on the type and diameter,

they may be furnished with either a rubber or lead gasket joint, and may be made with vertically poured and vibrated concrete or centrifugally cast concrete. On the basis of many years of experience and many millions of feet of pipe now in service, conservative design limits have been established that enable the pipe to withstand safely the internal pressure and external load conditions to which it is subjected.

Reinforced Concrete Cylinder Pipe

Reinforced concrete cylinder pipe, specification AWWA C300, is normally used for operating pressures in excess of 100 ft of head. The reinforcement consists of a continuous cylinder of steel sheet or plate, which produces a watertight membrane, surrounded by at least one cage of helically wound steel reinforcing rods. The design stresses are theoretical steel stresses in the cylinder and cage based on the assumption that the concrete will carry no tensile stress. For pipe bedded in a normal trench with 6 ft cover or less, the conservative design steel stress is 12,500 psi at normal operating pressure; 15,000 psi with line gate valves closed; and 17,500 psi during water hammer.

Prestressed Concrete Cylinder Pipe

Prestressed concrete cylinder pipe, specification AWWA C301, is normally used for operating pressures in excess of 100 ft of head. The reinforcement consists of a continuous cylinder of steel sheet, which produces a watertight membrane, and a helically wound cage of high-tensile steel wire. After the cylinder has been lined with a substantial thickness of concrete and this concrete properly cured, the high-tensile wire is wrapped directly on the steel sheet under a uniform high tension, thereby compressing both the steel sheet and the concrete lining. As a result of this prestressing operation, the compressive strength of the concrete can be used in design calculations, thus producing a saving in steel and a more elastic and stronger structure. In prestressed concrete, the usual design limitations on steel stress have little significance because of the truly composite nature of the resultant product. Consequently, it is more important to express design factors in terms of the internal pressure required to reduce to zero the compression in the concrete core. This internal pressure is customarily referred to as the zero compression pressure, or P_0. For pipe bedded in a normal trench with 6 ft cover or less, the conservative design conditions are: normal operating pressure, 0.8 P_0; line gate valves closed, 1 P_0; and during water hammer, 1.15 P_0.

Reinforced Concrete Pressure Pipe

Reinforced concrete pressure pipe, specification AWWA C302, is normally used for operating pressures of less than 50–120 ft of head, depending on the wall thickness. The reinforcement consists of at least one cage of helically wound steel reinforcing rods or of welded fabric. The design stresses are theoretical steel stresses based on the assumption that concrete will carry no tensile stress. For pipe bedded in a normal trench with 6 ft cover or less, the conservative design steel stress is 10,000 psi at normal operating pressure; 12,500 psi with line gate valves closed; and 15,000 psi during water hammer.

Long service experience and many tests to destruction have demonstrated the soundness of the design and the reliable uniformity of the materials, and give every assurance that the factors of safety provided are real ones

and not in any sense factors of ignorance. The foregoing design limitations have been proved safe and conservative by more than 30 years of experience with concrete pressure pipe in this country. During this period many pipelines have been operated under conditions as much as 50 per cent in excess of the design limitations cited without damage or failure. The conservatism of the design stresses is one of the chief reasons for the excellent experience record of concrete pipe in the water works field.

When trench conditions, depth of cover, or superimposed loads exceed the normal 6-ft cover condition, pipe is designed according to a combination internal-external load analysis and the design stresses for normal operating pressure, pressure with line gate valves closed, or pressure during water hammer are reduced accordingly. Inasmuch as such an analysis applies to only approximately 1 per cent of the pipe made, this discussion deals only with the standard allowable stress for resisting water hammer.

Conclusion

Water hammer is only one of many factors for which the engineer makes allowances in a pipe design. Certainly water hammer deserves as much analysis as the establishment of the hydraulic gradient and the carrying capacity of a pipeline. It is unsound engineering and economics to raise the cost of a pipeline arbitrarily by standard average allowance for water hammer. Sometimes this allowance will not be sufficient, and at other times it will be far too conservative. It is conceivable that the cost of a moderate-size transmission line could be unnecessarily increased half a million dollars by an arbitrary allowance for water hammer. A fraction of this money could be used to better advantage to insure positively that the pipeline will be closed down in 15 min, for example, instead of 2 min, thus practically eliminating water hammer.

Summary

Water hammer is a property of a pipeline that can be accurately analyzed and then controlled by proper operating procedures and adequate protective devices. The magnitude of water hammer is not necessarily a function of a size of pipe, a type of pipe, or an operating pressure. On the basis of years of experience, conservative design stresses have been established for the various types of reinforced concrete pressure pipe. The customary design stresses allowed for resisting water hammer are 40 to 50 per cent greater than those for operating pressure. The tailor-made properties of concrete pressure pipe should be fully utilized by the engineer when considering water hammer or any other design condition. The arbitrary use of standard allowances for water hammer may be either extremely extravagant or create a false sense of security.

General Discussion

Charles H. Capen

Chief Engr., North Jersey Dist. Water Supply Com., Wanaque, N.J.

How many water works men have ever happened to be standing beside a pipe when it was split by water hammer? It has been the writer's dubious privilege to witness such an occurrence, and it is somewhat terrifying, to say the least. The writer has also observed the effects of a sudden power failure on quick-closing check valves, has seen pressure gage needles swing

violently to the far stop and bend, has felt whole buildings tremble under the impact of water hammer, and, subsequently, has had to justify designs which sought to overcome some of these difficulties.

Like the solutions to many other problems, the methods of meeting water hammer effects consist of a series of compromises founded on certain known and assumed conditions. The answers may be as numerous as the people seeking the solution.

Water Hammer Incidents

A few illustrations will emphasize the awe in which many water works men hold the question of water hammer. One evening, while observing some effects of muddy water in a pressure filter plant, the writer was watching an operator make a wash. By some mischance, even though he was an experienced operator, he opened the filter inlet valve before closing the waste water valve to the sewer. With a series of reverberating noises, the waste pipe, an 8-in. cast-iron flanged line, eventually split longitudinally for a distance of several feet. Only the direction of the split prevented the writer from getting a thorough drenching. This loss of water acted as a temporary relief and the chief engineer at the plant eventually brought the pressures under control.

On another occasion the writer was in a new gatehouse, which was being tried out for the first time, when someone opened a large valve too quickly. A boiler factory could be considered a quiet place in comparison to the resulting din.

Force Main Design

In designing the new 72-in. Ramapo force main for the Wanaque, N.J., system, careful consideration was given to alternate designs of steel and reinforced concrete pipe. Both cylinder and noncylinder types of reinforced concrete pipe were contemplated because a considerable part of the line will have less than 100 ft normal working pressure. After reviewing the possibilities of water hammer, however, noncylinder pipe was not included.

Steel pipe was finally accepted on a competitive-bid basis. Normal working stresses of all types were studied and it appeared that, for most purposes, a thickness of not more than $\frac{3}{8}$ in. would be required. The final thickness selected was $\frac{7}{16}$ in., the extra amount being considered a safety factor to allow for both water hammer and corrosion. Some thought was given to the desirability of increasing this thickness to $\frac{1}{2}$ in., but twenty years of experience with the present pipelines of similar diameter and thickness led to the conclusion that added metal would not be economically justified.

Power Failures

The only actual break attributable to water hammer that has occurred in the present Wanaque system resulted from a power failure one sleety winter night, when the sudden closing down of one of the pumping stations connected to the main transmission pipe at approximately the midpoint caused a pressure wave to traverse the system and to be magnified at the lower or closed end. A 2-in. diameter, cast-iron plug, which was set in the line to permit passing of rivets during original construction, cracked. The stream issuing from this seemingly small orifice resulted in an unexpected amount of damage, including the washing out of some large concrete paving slabs on the street in which the pipe was laid. Oddly enough, this break occurred during the time that a

surge tank was being designed to prevent just such accidents. Later, when the surge tank had been completed and installed, similar power failures were found to have very little effect on the line.

At about that same time, three consecutive breaks occurred in a 20-in. cast-iron line that was designed to operate only under conditions of a low head and to serve as a suction line for some steam pumps. Many years after the main was installed, it was found desirable to put the line under pressure and to use it as a force main. When the centrifugal pumps used to put it under pressure were started, or when a valve on the line was suddenly opened or shut, breaks resulted. In each break it was found that the piece of pipe removed was rather irregular in thickness and, having been laid around 1903 or 1905, was cast before AWWA specifications came into general use. No further difficulties were experienced after the three initial breaks, although these, occurring in sequence during a month or less, were most discouraging at the time.

Conclusion

It has been pointed out that distribution pressures resulting from water hammer are frequently indeterminate. It would appear, therefore, that the deciding factor in determining the necessity for new standards of safety should rest largely with the individual system. If no reservoir or open body of water serves as a vent between a pumping station and the end of a closed system, caution is clearly indicated. It appears, then, that largely, or perhaps only, under such circumstances may the designing engineer be justified in calling for additional pipe strength and perhaps a revised set of water hammer allowances.

Laurence G. Lenhardt

Gen. Mgr. Board of Water Comrs., Detroit, Mich.

There are many causes of water hammer other than those arising from the water pumping stations, some of which may result in severe stresses in the distribution system as well as in the transmission mains.

In addition to the causes of water hammer given in the previous papers, the writer has encountered several others. Flushometer types of toilet mechanisms have been identified as the cause of trouble in at least two incidents in Detroit in recent years. One of these incidents resulted in three breaks in 6-in. lines in two blocks of a two-main residential street at 6:15 AM one cold winter day. Another incident occurred during World War II. Severe disturbances took place over a 4-sq mile area at rather regular times, particularly at approximately 10:15 AM and 2:30 PM. The disturbance was finally traced to a factory employing approximately 1,000 women who were given relief periods at this time. More than 80 flushometer valves were being used. The trouble stopped when the factory installed air tanks on its line.

In another situation, three breaks have occurred on a 12-in. line over a period of time, and always on Sunday. These breaks were finally traced to a packing-plant pump valve on the only source of water into the plant on Sunday. There was no relief for the sudden shock wave.

Car-washing establishments, laundries, and metal-pickling plants have also given trouble. Almost invariably, the disturbance originated with a quick-closing valve, although sometimes a faulty valve has caused the trouble. As these plants have services

up to 8 in. in size, the shock wave may be severe.

Contributing Factors

In many incidents involving known water hammer, the failures are not typical of bursting failures. Breaks have occurred where corrosion has been noted, and failure has occurred where pipe has been subjected to strain because of improper laying. If it had not been for the water hammer, however, there is no question that the pipe would have remained intact much longer, or perhaps might never have failed. In other words, the water hammer aggravates the condition by acting as the trigger mechanism.

Small Pipe

Generally, the smaller pipe in a distribution system is designed for an average velocity of 1.25–1.50 fps, whereas the larger transmission mains may be designed for velocities of 5.5–6 fps. Because of fire flow conditions, however, velocities in 6- and 8-in. mains may be increased to as high as 10–12 fps. Transmission main velocities rarely increase to this extent unless a main breaks.

Water hammer originates more frequently on a distribution system than on transmission mains because there is more access to the distribution system. Every customer or hydrant is a potential source of disturbance. As the thinner-walled, small pipe loses a much larger proportion of its strength than large pipe on account of corrosion or deterioration, it seems highly advisable to protect small piping, as well as the entire system, by eliminating dead ends wherever possible. Dead ends can cause reflected shock waves which may possibly compound and result in disaster. Storage tanks or standpipes riding on the line can afford relief.

Usually small pipe is bought according to standards which incorporate provisions for water hammer. The writer has found that some of the lighter pipe does not incorporate sufficient safety provisions. As the difference in cost laid is negligible considering the prospective life of the pipe, the Detroit Board of Water Comrs. has been specifying a heavier pipe than the pressures would seem to require and feels it is saving money. Roughly, 16 per cent more metal is obtained for an 8 per cent increase in cost of pipe, which means an approximate increase of only 4 per cent in overall cost of pipe laid. The writer believes the American Water Works Assn. could well review the adequacy of its standards for the smaller sizes of pipe.

Conclusion

Large pipelines—particularly long transmission mains from pumping stations—should be made the subject of engineering study and analysis. All factors that might contribute to water hammer, such as pressures, elevations, valves, tanks on the line, large services, type of pumping equipment, and sources of power should be recognized. Only after all factors have been evaluated should decisions be made on thickness, class, or strength of pipe. It also seems to be false economy to skimp on larger lines. One break avoided can readily pay for the extra cost, to say nothing of losses arising from interruption of service.

Samuel B. Nelson

Asst. Chief Engr., Dept. of Water and Power, Los Angeles, Calif.

There is no question that the allowances for water hammer now provided in closed water carriers of various materials should be reviewed. The expe-

riences of water works operators in dealing with water hammer should be of great value in reaching a solution. The writer feels that means are available to minimize water hammer effects.

Defective Valves

The Los Angeles Dept. of Water and Power has encountered some difficulty with a few large consumers—for example, a large oil company caused water hammer trouble because it had installed in its line a valve that closed too rapidly. The company was taking approximately 2 cfs at the time of the difficulty. The trouble was corrected when the valve was replaced. Water works operators should inspect thoroughly water mains on consumers' premises and should be particularly alert for consumers who make use of main pressures to pump to higher levels. Pumps that operate to maintain proper levels in service tanks must be carefully watched to prevent an on-and-off condition.

Automatic pumping plants should have hydraulically operated valves to reduce water hammer effects. Time relays set to 5 or 10 sec should be installed if critical on-and-off conditions exist, such as in maintaining proper service tank levels.

Fire Hydrants

Fire department usage should be carefully considered, as fire hydrant valves generally do not lend themselves to throttling conditions. Service from fire hydrants should be analyzed to prevent or reduce to a minimum the possibility of quick-closing operations. The use of certain devices that would reduce water hammer on fire hydrant services should be investigated. The Los Angeles Dept. of Water and Power requires tank trucks which fill from hydrants for street flushing purposes to install at the hydrant a special valve which minimizes water hammer.

The Los Angeles water system has approximately 80 pressure zones. In the entire system there are approximately 150 regulator stations. The majority of the regulators are protected with a relief valve to take care of surges but not necessarily water hammer. These relief valves occasionally stick in open position and cause trouble.

Trained Crews

Los Angeles has seven regulator crews and 21 gate crews, the only employees who are permitted to operate the gates. These crews have been trained in gate operation. When breaks occur, the tendency is to operate the shutoff too rapidly to save further property damage; trained men know the fallacy of such a procedure.

Water Hammer Tests

In May 1952 the Los Angeles power system started to test the effects of water hammer in a penstock, having a diameter from 96 to 108 in., that is between two power plants in the gorge of Owens River, approximately 300 miles north of Los Angeles. Results of these tests will be informative.

Conclusion

The writer feels that water works operators' experience with water hammer would be of considerable assistance in arriving at the answer to the question: Is it necessary to make allowance for water hammer conditions in the design of pipelines and, if so, what are the proper allowances for various materials? The allowances used should reflect a reasonable consideration of the hazard against which they are protecting. This type of information should be accumulated and analyzed by a committee of the Association.

Increasing Water Resources Through Weather Modification

By Irving P. Krick

A paper presented on May 7, 1952, at the Annual Conference, Kansas City, Mo., by Irving P. Krick, Pres., Water Resources Development Corp., Denver, Colo.

INCREASES in the consumption of water for all purposes, both in the United States and in other parts of the world, necessitate a continuing search for additional water resources. In many areas of the world, the consumption of water exceeds the amount available from normal rainfall, in spite of adequate storage and distribution facilities. One line of investigation for increasing water resources is, of course, the direct distillation of sea water to produce fresh water (1, 2). Such distillation is, at present, a costly process.

Rain Increasing

During the last six years significant progress has been achieved in weather modification, particularly rain increasing, which has become one of the important divisions in this field of investigation. The history of this development, the principles of it, control of weather modification operations, and evaluation of the results form the subject matter of this paper. Inasmuch as nature's rain-producing mechanisms employ the distillation of sea water to fresh water, there is a definite parallel between the objectives of weather modification for increasing rainfall and efforts being made to distill sea water directly. The author favors the former method because of the lower costs and the excellent distribution system which the atmospheric circulation already provides for water that is to be precipitated.

An investigation of nature's distillation processes indicates a very low efficiency, a fact which explains why the present rather puny efforts at weather modification can yield results that sometimes have been considered spectacular. Nature has difficulty in precipitating even 1 per cent of the moisture in air streams passing overhead during the most favorable storm situations and, during periods of no rainfall, vast amounts of water suspended in the atmosphere pass overhead without any precipitation taking place. At present there are no means of tapping this source of moisture when nature is unyielding. It is only during periods of natural storminess that man is able to assist nature in giving up a portion of this almost endless supply of moisture. Nevertheless, assuming that nature may be 1 per cent efficient in producing rainfall, if man, by artificial stimulus, can increase that efficiency to 2 per cent, the amount of water that reaches the earth's surface has been doubled. Thus, in the author's opinion, obtaining sufficient water for all

human activities is no longer a problem. The development of storage and distribution systems to handle additional water in semiarid areas of the world remains the principal problem to be solved.

Historical Background

A scientific approach to problems of weather modification began as early as the 1890's, when patents were issued in both the United States and Germany on devices for projecting dry ice into the clouds (3). Certainly these inventors understood or suspected the role played by clouds containing a mixture of ice crystals and supercooled water droplets in nature's rain-producing mechanism. These early attempts to induce precipitation were thwarted because of a lack of current information on the state of the atmosphere. It was presumed by early experimenters that one could shoot projectiles loaded with liquid carbon dioxide under great pressure into likely-looking clouds, so that, when the projectiles burst, the sudden expansion and resultant cooling of this material would produce dry ice which would chill the air and result in the formation of ice particles.

Without an accurate knowledge of temperature and moisture distribution in existing cloud systems, it was impossible to determine when, where, and how much material should be used. Thus, interest in these early efforts lagged and finally died out altogether.

During the first third of the twentieth century, however, considerable progress was made in the measurement of upper atmospheric conditions, first by balloons, then with aircraft, and finally, in the years before World War II, by radio-equipped sounding devices. Also during this period theories which gave more credence to the role of ice crystals in clouds of supercooled water droplets as a precipitation mechanism were developed (4). An attempt at artificial rain production is described in the literature in 1931, when a Dutchman, Veraart, dispersed dry-ice pellets into supercooled clouds from an aircraft flying above the clouds (5). In an effort to verify his results, Veraart obtained rainfall measurements directly under the clouds which were seeded and compared these reports with rainfall from surrounding areas. It was his opinion that a maximum in the rainfall pattern was attained in the vicinity of his operations. On the basis of these experiments, he appealed to the Dutch government for financial support to continue and extend this operation. His efforts proved fruitless and again interest in artificial rain production diminished.

The subject was revived and stimulated by the experiments of the General Electric research laboratories in Schenectady, N.Y., in 1946, under the direction of Irving Langmuir, Vincent Schaefer, and Bernard Vonnegut (6, 7). The introduction of dry ice into a cold box filled with tiny supercooled water droplets resulted in the formation of ice crystals. This was only the beginning of a vast experimental program during the succeeding six years. At present considerable evidence which leads to the conclusion that economically significant results are being achieved already through an application of the knowledge derived from the early General Electric investigations has been amassed.

When General Electric announced its first experiments in this field, the author was Professor of Meteorology at the California Institute of Technology. Over a period of many years this

meteorological group had concerned itself not only with the study of basic meteorological phenomena but also with the application of this knowledge to related problems of agriculture, industry, and commerce. The General Electric announcement stimulated the group to explore the potentialities of weather modification in agriculture, ranching, and the electric-power industry. The group first duplicated experiments announced by General Electric laboratories and then seeded clouds with dry ice from aircraft. Results of these independent investigations confirmed the General Electric thesis. The California meteorological group next determined to engineer these discoveries into a practical operating program on the basis of long experience with atmospheric problems. In order to accelerate work in this and other fields of applied meteorology, in the spring of 1948 the Cal Tech meteorology staff joined the author in forming the American Institute of Aerological Research, a nonprofit research organization devoted to the application of atmospheric knowledge in various fields of human endeavor. The American Institute of Aerological Research has remained the research and development unit behind the operating companies with which the author has been associated in the field of weather modification. In 1948 and 1949 this group supervised cloud seeding operations by aircraft in Arizona, California, and Mexico (8, 9). Limitations on using aircraft for large-scale operations became apparent during this period. Therefore, considerable effort was expended during late 1949 and the spring of 1950 in the development of ground equipment for continuous and properly controlled introduction of cloud-seeding materials into an air stream. Investigations relating various meteorological situations to economic aspects of weather modification were pursued. From these researches, operational procedures and methods of evaluating results were derived.

Commercial Weather Modification

It was during this period that the group gained sufficient confidence in the outlook for large-scale weather modification operations to justify the formation of a company to pursue projects of this type on a commercial basis. The Water Resources Development Corp. was established in the spring of 1950 and undertook its first operation in the Horse Heaven Hills in eastern Washington in June 1950. This project was supported by a single wheat-farming operation and covered an area of approximately 100,000 acres. The region is one of low annual rainfall, approximately 7 in., but unusually fertile soil. Thus, in the years of more than normal rainfall, good crops can be grown, but dry years have proved disastrous for past generations, placing the area in a distinctly marginal category for wheat farming.

Although these early operations in the Horse Heaven Hills were strictly experimental, they were regarded by many as highly successful. Two storms were operated, one occurring June 6–8 and the other June 11–12. The rainfall pattern for the two storms was centered over the target area. Rainfall amounts attained values of approximately 430 per cent of the June normal in the target area, diminishing rapidly in all directions away from the target area. Normal rainfall for June is approximately ½ in.; thus, the target enjoyed an excess of 2 in. of rain during this period.

Before operations were started, official crop estimates anticipated yields of 7–8 bu per acre. The final harvest ranged from 20 to 27 bu. In spite of the fact that a detailed evaluation of this operation could not be developed for several months following it, news of the work and its apparent success spread rapidly throughout the country. This set off an expansion and development of cloud-seeding experiments in the western United States that caused an increase in the area operated by the author's organization alone from the initial 100,000 acres in eastern Washington in June of 1950 to more than 300,000,000 acres by June of 1951.

Experimental data assembled during the past two years have provided ample means of investigating the limitations and potentialities of rain increasing, the important aspect of weather modification. Thus, it would seem worth while to outline in some detail those precipitation mechanisms in nature upon which present weather modification operations are based, as well as a discussion of the fuels, equipment, and operating procedures utilized. It will also be useful to describe some of the evaluation procedures which have proved fruitful in segregating induced from natural precipitation during these operations.

Principle Involved

Present weather modification operations aimed at increasing natural precipitation utilize the concept that rainfall may be induced over wide areas only during natural storm conditions. Therefore, an understanding of nature's rain mechanisms is essential to successful operations. Broadly speaking, nature precipitates water from the skies in two stages, the first stage being droplet or ice crystal formation by a process known as nucleation, and the second, the growth and coalescence of ice crystals or drops thus produced until their weight is sufficient to enable them to fall through the air stream transporting them. Nucleation involves the formation of drops or ice crystals upon foreign matter, such as salt particles, dust, or other chemicals, in the atmospheric air streams. These particles act as small nuclei which attract moisture to form water drops at temperatures above freezing or ice crystals at temperatures below freezing. The efficiency of this nucleation process is a function of temperature and the material upon which the moisture collects. In nature, the temperature at which the formation of ice crystals or sublimation nuclei is most commonly completed is approximately −13 F. Thus it is possible to produce ice crystals at temperatures much closer to the freezing point, 32 F, if sublimation nuclei effective at temperatures close to freezing can be artificially dispersed through supercooled cloud formations (water droplets at temperatures below freezing). Similarly, it is possible to spread artificial condensation nuclei through clouds having temperatures above freezing for the purpose of increasing the number of water drops produced by the nucleating process or to vary the size of the drops thus developed. At present, however, most weather modification operations for increasing natural rainfall depend upon the use of artificial sublimation nuclei. This paper, therefore, will consider only the application to supercooled clouds.

Most rain-producing clouds in nature that attain altitudes at which temperatures are below freezing have passed through the condensation stage before ice crystals are developed.

Thus, the cloud drops attain temperatures below freezing, and, when ice crystals appear, the cloud becomes a mixture of ice crystals and water droplets. Because of the difference in the saturation vapor pressure over ice and water, ice crystals grow at the expense of the water drops. Generally speaking, large ice crystals in a cloud heavily laden with closely spaced water drops will grow rapidly. Tiny ice crystals in a cloud sheet having small and widely separated water drops will grow more slowly and the interval of time between the nucleation stage and final precipitation will be relatively long.

To date, several substances not found in nature have been used effectively as ice crystal producers in supercooled cloud masses. Those used principally are dry ice and silver iodide. Dry ice operates by cooling the air with which it comes in contact to temperatures below −40 F. At these temperatures, ice crystals will form spontaneously in saturated air. Silver iodide, on the other hand, can be vaporized to produce a myriad of tiny sublimation nuclei which will act to produce ice crystals in saturated air at temperatures of approximately 27 F. For large-scale operations, silver iodide has an advantage over dry ice in that it can be dispersed into an air stream in effective nucleating concentrations over relatively wide areas. It can be introduced into cloud masses from the earth's surface because of the natural vertical motions and turbulent diffu-

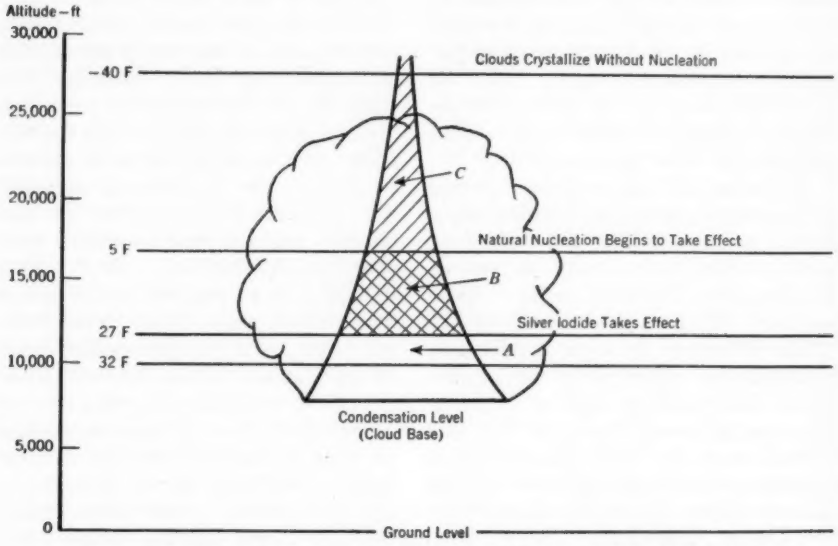

Fig. 1. Temperature Levels for Natural and Silver Iodide Nucleation

The italic letters refer to the following: A—*water content between 32 and 27 F, a range which is unaffected by nucleation;* B—*water content between 27 and 5 F, a range which can be affected by silver iodide nucleation; and* C—*water content between 5 and −40 F, a range which can be affected by natural nucleation.*

sion present in a storm situation, whereas dry-ice pellets must be introduced from the tops of the clouds by aircraft or other means and are quickly dissipated in their fall through the air. Thus, their effects are very limited in time and space and are usually unproductive of the important large-scale influences required if cloud seeding operations are to be economically feasible. For these reasons, the field operations of the author's firm have been restricted to the use of silver iodide, and subsequent discussion in this paper will deal only with weather modification procedures using this nucleating agent.

Silver Iodide Nucleation

Figure 1 illustrates the principle of artificial nucleation using silver iodide. The ordinates indicate altitude and show characteristic temperature levels in the atmosphere over the United States on a typical summer day. The cloud formation may represent either an individual cloud mass or extensive cloud sheets associated with a major cyclonic storm. Temperature values shown in Fig. 1 are not necessarily characteristic of the corresponding altitudes for every weather situation. In winter, for example, they may be much lower. In dealing with the effects of silver iodide on supercooled clouds, the important consideration is the thickness of the cloud mass above freezing levels in the atmosphere where silver iodide takes effect as a sublimation nucleus. The triangular form drawn inside the cloud is used to illustrate the variation of moisture content with altitude in the atmosphere. It shows that at lower levels there is more water available for condensation and precipitation than at higher levels in the atmosphere because, at the cold temperatures characteristic of high altitudes, air will not hold as much water vapor in suspension as it will at the warmer temperatures found in lower altitudes.

In the cloud mass in Fig. 1 there are three critical zones in the regions where temperatures are below freezing. In the lower portions of the cloud, in the range between 32 and 27 F, the water content in the cloud is unaffected by artificial nucleation because silver iodide crystals do not begin to act as sublimation nuclei until the temperatures are colder than 27 F. In the range between 27 and 5 F, the water content can be affected by silver iodide nucleation. Thus, this is the zone within the cloud mass in which silver iodide will form ice crystals. On the other hand, natural nucleating materials do not begin to take effect until the temperatures are colder than 5 F and, therefore, are ineffectual within this layer of cloud. At temperatures colder than 5 F, water vapor in the cloud can be affected by substances occurring in nature which produce ice crystals. This effect is not complete, however, until temperatures are near − 13 F, so there is still, in this segment of the cloud, an action of silver iodide in augmenting nature's ice crystal production. Finally, at levels of approximately − 40 F, clouds crystallize without nucleation of any kind, because this is the temperature level at which ice crystals will form spontaneously in saturated air.

Because of the distribution of water vapor in the atmosphere, it can be seen that the segment of cloud affected by artificial nucleation contains much more water than the higher portions of the cloud influenced by natural nucleation. Consequently, the proportion of water that is precipitated to the earth by the artificial nucleation proc-

ess often exceeds that which would have fallen through the effects of natural nucleating materials in the atmosphere. In general, the ratio of induced precipitation to natural precipitation is greater in winter than in summer because the greater proportion of cloud mass lies at levels at which temperatures are below freezing. This ratio is greater in high latitudes than in low latitudes for the same reason.

by cloud-seeding efforts with silver iodide.

Seeded and Unseeded Clouds

The effects of silver iodide cloud seeding can readily be recognized because of the transformation that takes place in a treated cloud. Before nucleation, the cloud is composed chiefly of supercooled water drops. Following the seeding operation, a portion of

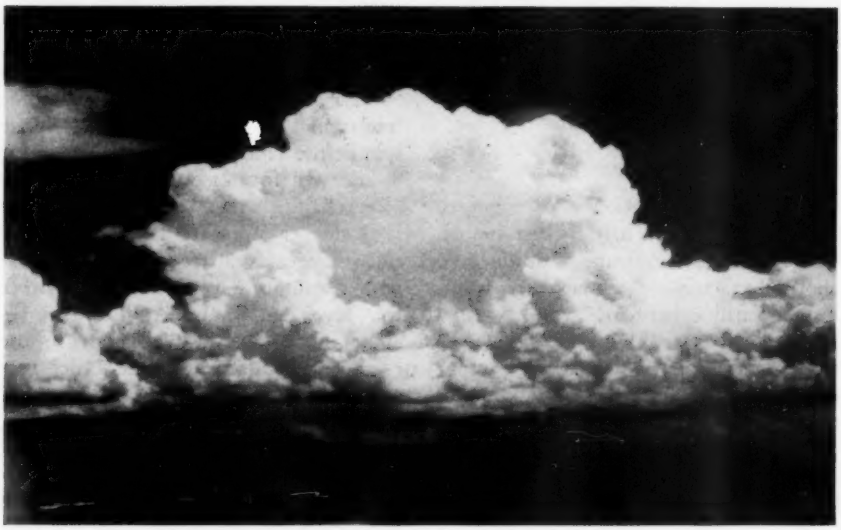

Fig. 2. Untreated Summer Cloud Formation

Untreated clouds show a distinct or hard outline against the sky.

The author's company attributes its success in snowpack operations in mountainous areas of the United States to this phenomenon. On some occasions, ratios of induced to natural precipitation in these operations will range as high as ten to one. In the tropics during summer when a relatively small proportion of the moisture in cloud formations lies at altitudes above the freezing level, natural precipitation has been increased only 15 or 20 per cent

the cloud above freezing levels is transformed into ice crystals. Ice crystal clouds have a wispy, fibrous appearance, whereas clouds composed of water drops, even at temperatures below freezing, have hard, well-defined outlines. These differences cannot be observed from the ground during a general storm when the sky is completely overcast and the ice crystal clouds lie embedded in the cloud cover. On the other hand, during summer

thunderstorm situations or whenever the cloud forms are isolated, it is relatively simple to discern these differences. Figure 2 illustrates a typical unseeded summer cloud formation. Note the distinct outline of the cloud against a clear sky background. Figure 3 shows a seeded summer thundershower in New Mexico in 1950. This storm was nucleated from ground equipment located approximately 50 miles to the left of the picture. The ice crystal texture in the central and upper portions of the cloud mass can easily be discerned. Adjacent portions of the growing cloud mass are composed of water drops and present the typical sharp outline. This situation illustrates the mixture of ice crystals and water drops so effective as a rain-producing mechanism.

Fig. 3. Summer Cloud Formation Nucleated With Silver Iodide

Seeded clouds have a wispy, fibrous appearance.

Although such cloud formations are susceptible to weather modification operations, in general, the most important successes are attained in storm systems in which cloud sheets form a solid mass covering thousands of square miles. Nevertheless, it is useful to conduct experiments with such marginal, isolated cloud formations in order to trace silver iodide smoke plumes from ground generators by observing their effects upon cloud masses. It has been found valuable to photograph these operations and to subject them to rigid measurements for the purpose of developing sound operating procedures for use in more productive weather situations.

Silver Iodide Production

In cloud-seeding operations it is convenient to vary the size and number of silver iodide crystals dispersed through an air stream, depending upon the particular weather situation. Sev-

eral methods of vaporizing silver iodide are utilized for this purpose by various experimenters. Silver iodide, in its pure form, is a yellowish powder, but is not used in this state for cloud seeding. It is usually vaporized by subjecting it to a high temperature in order to produce the proper size and number of crystals for the nucleating process. The optimum temperature is approximately 2,500 F. Various methods are in use, ranging from an acetone solution of silver iodide that is passed through a hydrogen or butane flame which burns at approximately 1,800 F, to the burning of sized foundry coke impregnated with a solution of silver iodide in acetone in a furnace in which the optimum temperature of 2,500 F is easily attained. The author's organization utilizes the latter procedure.

In order to insure proper crystal sizes and output from the vaporizing equipment, rigorous standards are maintained in the laboratory where all lots of fuel are tested before shipment to the field. Samples of impregnated coke are burned as they come from the production line at the fuel plant. A sample of the air being emitted from the furnace is taken with a syringe device. The test is made in an ordinary cold box where a supercooled cloud has been produced, composed of droplet sizes similar to those encountered in the free atmosphere under operating conditions. The temperature of the cold box is maintained at approximately + 5 F, a range which will be unaffected by nature's sublimation nuclei but which will result in complete nucleation by silver iodide crystals.

The supercooled cloud in the cold box is subjected to a treatment of silver iodide crystals from the sample of air taken from the vaporizing furnace. Immediately, scintillating ice crystals which grow at the expense of tiny supercooled water droplets in the cloud chamber appear. Ultimately, these ice crystals precipitate to the bottom of the box and are collected on glass slides. Viewed through a microscope, a physical count of the crystals can be made and their sizes observed. By measuring the distribution of the crystals on the glass slides, a calculation of the number of silver iodide particles being produced per unit time from a given fuel lot can be made. A satisfactory result ranges between 10^{14} and 10^{16} crystals per minute.

Fig. 4. Silver Iodide Generator

Coke impregnated with silver iodide dissolved in acetone is burned at a temperature of approximately 2,500 F.

Silver Iodide Generator

The silver iodide fuel, composed of ¼-in. foundry coke impregnated with

controlled amounts of silver iodide dissolved in acetone, is burned in a crucible furnace that is fed from a hopper. The operation of this vaporizer must be simple and the unit must be of rugged construction for field use. Figure 4 illustrates the unit currently used by the Water Resources Development Corp. Basically, it is composed of a fuel hopper, feed mechanism, and vaporizing furnace. The feed mechanism and a blower for maintaining proper temperatures in the furnace are powered by either a storage battery or ordinary electric current. By feeding the fuel into the furnace at a rate of approximately 1 lb per hour, proper crystal counts are obtained for operations under most weather conditions. Obviously, this equipment must be located so that the proper number of silver iodide crystals arrive within a supercooled cloud mass to deliver increased precipitation to specified areas. The method used to control the operation will be discussed in another section of this paper.

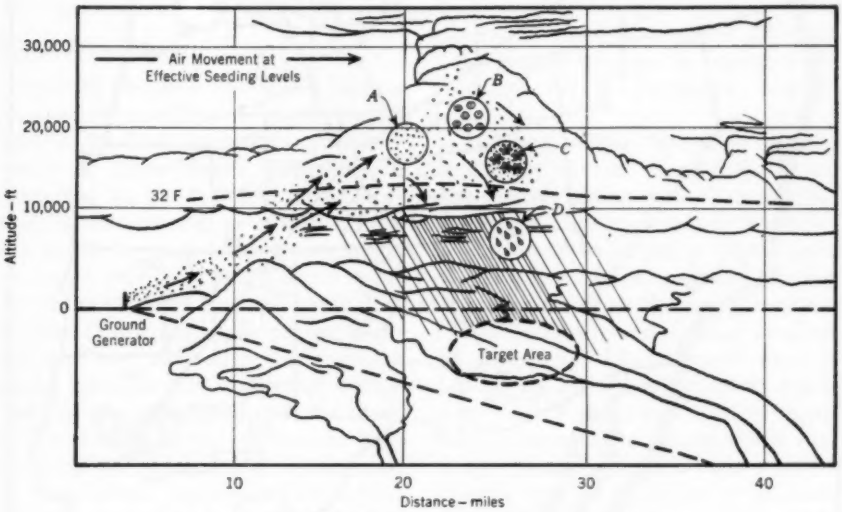

Fig. 5. Silver Iodide Ground Generator in Action

The ground generator projects silver iodide particles into the atmosphere at the rate of approximately 10^{15} per minute. The particles are carried into the clouds and diffused by natural turbulence and updrafts within the cloud. Each particle becomes a potential snowflake at temperatures near 20 F or lower. The generator is effective over several hundred square miles. The italic letters in the figure refer to the following: A—*silver iodide crystals or nuclei;* B—*nucleated supercooled water droplets that are developing into hexagonal ice crystals;* C—*ice crystals becoming snowflakes which will fall;* D—*snowflakes turning to rain below the freezing level.*

Figure 5 shows schematically a typical field operation utilizing ground generating silver iodide equipment. The vaporizing unit is shown on the left-hand side of the diagram at ground level. The silver iodide particles, which are invisible, are drifting down-

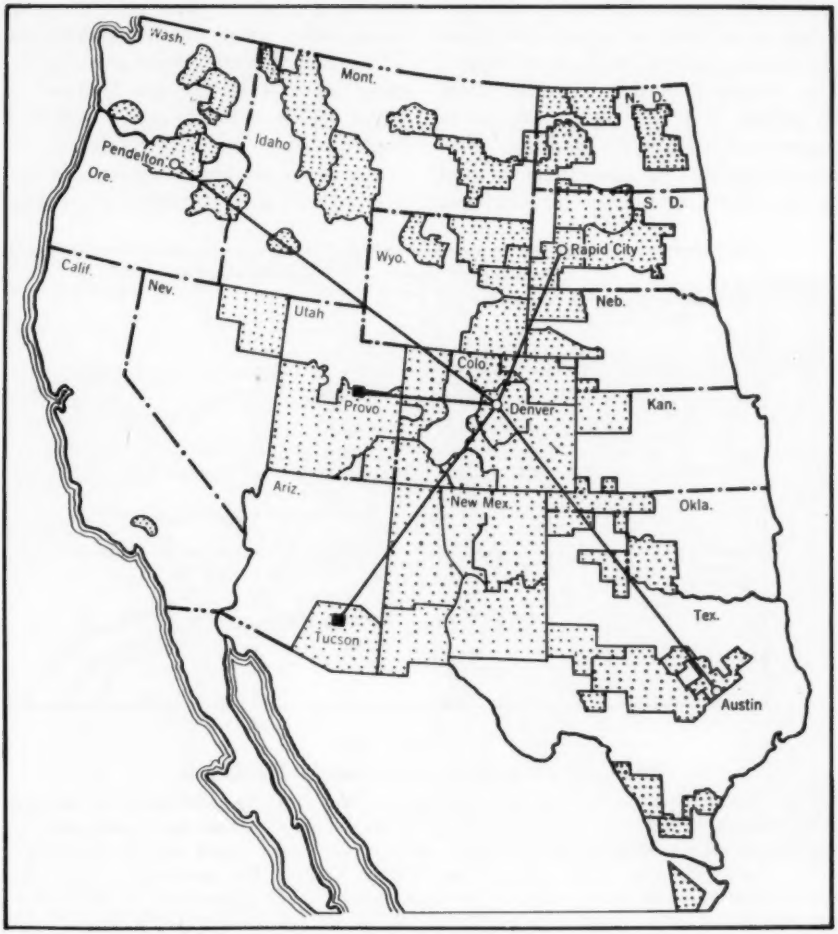

Fig. 6. Projects and Regional Control Areas

The shaded portions represent projects active in 1951–52. ○ represents a regional office and ■ a satellite base.

wind toward the right of the diagram and, at the same time, are rising into the cloud mass in response to the natural turbulence and convection that are always present during favorable cloud-seeding situations. Lateral diffusion of the smoke plume is shown by the fanlike segment in the horizontal projection. As the silver iodide particles ascend to a level at which temperatures in the cloud mass are below 27 F, they begin to form tiny ice crystals. These crystals grow at rates that depend upon their initial size, the water content in the cloud, and the distance between droplets in the cloud. Assuming that

the operation has been properly controlled, these ice crystals attain sufficient size to fall from the cloud as snowflakes at a point at which the maximum effects of the operation are concentrated over a specified target area. The precipitation arrives as snow if the temperatures are below freezing at the ground, or as rain if the temperatures are above freezing.

Field Operations

One of the most important aspects of weather modification is the proper control of field operations. Trajectories of silver iodide particles are computed to yield proper concentrations of the material at effective seeding levels in treated cloud formations to insure maximum increases in natural rainfall over designated areas. In a sense, this operation is similar to an artillery fire control problem. One might consider the vaporizing equipment as the field piece and the silver iodide particles as projectiles. In both problems the projectiles are influenced by atmospheric conditions. Silver iodide particles, however, do not leave the generator with any velocity and, therefore, are completely at the mercy of horizontal and vertical wind currents, from the surface up to the cloud formations where they take effect. It is important that the operator of a cloud-seeding project have at his disposal current information on the state of the atmosphere from the ground to the top of the cloud formations to be seeded. These data must include wind direction and speed at all altitudes and a knowledge of the vertical components of motion in the air stream, as well as the degree of turbulent diffusion. Temperature and moisture distribution within the air stream is also vital in a determination of the moisture and extent of the cloud mass above freezing levels.

Location of the silver iodide generators in relation to specified target areas becomes a function of the particular atmospheric conditions prevalent during each operating period. It is necessary, therefore, to maintain current meteorological information at the operating headquarters in order to determine when and where silver iodide generators can be operated effectively for a particular weather situation.

A cloud-seeding operation is controlled by current conditions in the atmosphere rather than by a weather prediction. Although the art of weather prediction has reached a high degree of perfection, there are still inherent inaccuracies which do not permit the operation of a cloud-seeding program on this basis. Field crews may be alerted by anticipated weather conditions, but final orders for operation must be based upon the measured state of the atmosphere from hour to hour. Control of the operation is achieved through the use of current U.S. Weather Bureau information received at operating headquarters over Civil Aeronautics Authority teletype circuits and supplementary data from generator operators and field technicians. These weather circuits can be made available to any properly qualified operator through a licensing arrangement with the U.S. Dept. of Commerce. The data thus provided on a 24-hour, 7-day-a-week basis permit the cloud-seeding operator to maintain complete contact with the changing weather situations affecting his target areas.

Surface and upper-air charts are prepared for the North American continent and adjacent ocean areas several

times daily in order to maintain a constant watch on the weather. These charts are compiled from surface and upper-air observations taken at approximately the same time. Thus, each analysis provides a sort of snapshot picture of the atmosphere at a given instant. Movements of the various air streams interacting to produce the major storm areas which cross the country are readily delineated. Accurate information on temperature and moisture distribution in the upper atmosphere, as well as wind movements, is studied to determine cloud-seeding opportunities.

The current weather data that come to the headquarters of the author's organization over the Civil Aeronautics Authority–U.S. Weather Bureau teletype installation are studied hour by hour as a check against the analyzed weather charts which are prepared at 6-hr intervals. In the control room at the headquarters, weather analysts and the cloud-seeding controller confer to determine how operations will be set up for any particular target area as a function of the current weather situation. Appropriate symbols which locate the several hundred stationary silver iodide generators in use for various cloud-seeding projects operated by the company are placed on the control board. These generators are arranged so that they can target effectively any project under most weather conditions. This board is similar to those used in the war rooms of various military headquarters during World War II. The location of the equipment, the time when it was last serviced and inspected by a field maintenance man, and its current operational status may be determined at a glance. Thus, a cloud-seeding controller coming on duty at any hour of the day or night can grasp the current operating position immediately.

Operations of the author's organization comprise 40–50 projects in seventeen western states. Consequently, the establishment of communications necessary to the starting of generators in different parts of the country at the right time becomes a considerable problem. For this reason, the operating area has been divided into a number of segments. Figure 6 shows these divisions and the active projects in 1951–52. Although the entire operation is controlled from the Denver headquarters, regional offices put into operation the generating equipment within their sectors. In this sense a certain degree of decentralization is achieved. Instructions to regional offices are transmitted from Denver either by telephone or teletype. Although field operations are handled primarily from generators located at fixed points and operated by local residents in the area, occasionally it is convenient or necessary to operate mobile field units. These crews also carry out maintenance and service functions and supply fuel to generator operators throughout the territory.

Preoperational Studies

Positioning of equipment and development of operating procedures for each project area must necessarily precede actual operations. It is desirable, therefore, to conduct a preoperational analysis of each situation before launching a field program. This analysis must include: [1] a study of historical weather records of the area to determine the frequency and distribution of various weather processes and their associated rainfall patterns in order to evaluate cloud-seeding potentials during different seasons of the

year; [2] the development of relationships between the cloud-seeding potentialities of the area and its economy. This phase of the study permits the operator to determine the value of additional water to the project area and the ability of the area to utilize it.

The end result of the preoperational analysis is to develop equipment requirements and operating procedures for each project and to determine the ratio of benefits to costs so that the project will be sound financially. Rather interesting figures have been evolved from these analyses showing the increases in rainfall required to pay for a project as a function of the economy of the region. In general, a highly developed segment of the country with a moderate annual rainfall justifies cloud seeding costs provided a precipitation increase of 0.5 per cent of normal is produced. In some of the more arid areas where annual rainfall is low and very little development from a standpoint of farming and ranching has taken place, it may take a 5 or 6 per cent increase in the average annual rainfall to justify a program. These figures are based on a minimum project area of 5 million acres. If the area of operation is smaller, the costs are proportionately higher and, conversely, the larger the operating area, the smaller the unit cost.

In general, a satisfactory program can be financed for approximately 1 cent per acre per year. Usually, associations sponsoring weather modification projects are obliged to assess the membership at rates ranging from 5 to 25 cents per acre because participation seldom approaches 100 per cent within the project area. Of course, this implies that many people are "free riders." Some states are considering legislation which will permit a uniform assessment to cover costs of such projects. Utah has already enacted a law which permits county commissioners to levy a 1-mill assessment to help cover costs of rain-increasing operations. A more satisfactory method would appear to be the creation of a system of weather modification districts based on the pattern already established by soil conservation districts. This method would eliminate "free riders" and leave control at the level of the individual citizen.

Evaluation of Projects

Perhaps the questions uppermost in the minds of most people supporting rain-increase programs are: "How much has the operator been able to improve upon nature?" and "What does this mean in dollars and cents to the subscriber?" During the two years that large-scale field operations have been in progress, evaluation procedures have been evolved in an attempt to answer these queries. Early methods were almost completely subjective—for example, the use of "before" and "after" pictures of a project area. More recent investigations have been much more objective and scientific in their approach, largely because of the mass of experimental data that has become available for operational analysis.

An early attempt at objective evaluation of cloud-seeding results was based upon comparisons between rainfall within a target area and the pattern outside it. This method, illustrated in Fig. 7–9, was applied to operations in eastern Washington in June 1950, described earlier in this paper. Figure 7 shows a portion of Washington and Oregon, including the target area located in eastern Washington. The operation took place

June 6–8, 1950, during the passage of a storm area which moved into western Washington and swung southeastward through the target area, recurving to the east and northeast as indicated by the long, curving arrow. The rainfall pattern that occurred during this storm is shown by lines joining points of equal precipitation, expressed as a percentage of the normal June rainfall. In this way, effects of rainfall variations resulting from terrain are minimized.

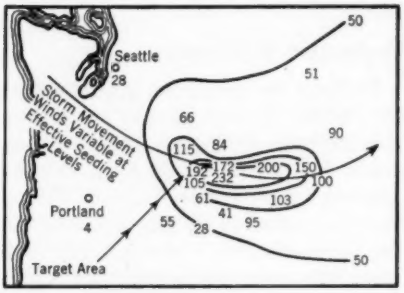

Fig. 7. Silver Iodide Cloud Seeding in Washington and Oregon June 6–8, 1950

The operation took place between June 6 and 8, 1950 during the passage of a storm area. The rainfall pattern that occurred during this storm is shown by lines joining points of equal precipitation, expressed as tentative percentages of the normal June rainfall.

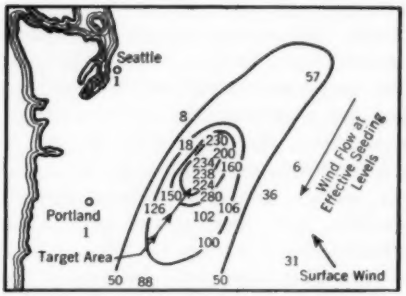

Fig. 8. Silver Iodide Cloud Seeding in Washington and Oregon June 11–12

The rainfall pattern is shown by lines joining points of equal precipitation, expressed as tentative percentages of the normal June rainfall. Success was greater in calculating the position of the generator even though the weather situation was entirely different from that of the previous storm.

It is well known that rainfall west of the Cascade Ranges in Washington and Oregon greatly exceeds that in the flat, semiarid areas east of the Cascades. By expressing the rainfall as a percentage of normal, however, this difference is largely eliminated from the pattern. Figure 9 shows that the maximum in the rainfall pattern for this storm occurred somewhat east of the target area. Nevertheless, an amount equal to approximately 192 per cent of the June normal occurred over the target area, whereas, in regions west of the Cascades, such as Portland and Seattle, the values were only 4 and 28 per cent, respectively—in fact, the rainfall decreases very sharply in all directions from the maximum. The author infers from this chart that the operation was unsuccessful in locating the absolute maximum of the rainfall pattern precisely in the target area, which was relatively small, but that some measure of success was attained, as the target area is very close to this maximum.

Recognizing this deficiency in accurately targeting the project, calculations were made preceding the next operation to correct for the movement of the seeded air stream during the time required for ice crystal growth between nucleation and ultimate pre-

cipitation. Figure 8 illustrates the rainfall pattern for the succeeding operation, June 11–12, 1950.

It would appear from this pattern that success was greater in calculating the positioning of generating equipment even though the weather situation was entirely different from that of the previous storm. The figure indicates that the wind at ground level was blowing from the south southeast, but that the wind flow at effective seeding levels—that is, at altitudes in the

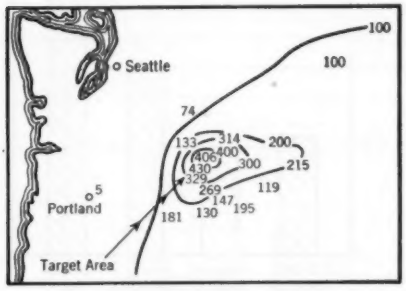

Fig. 9. Combined Effect of Silver Iodide Seeding

The rainfall patterns of Fig. 7 and 8 are integrated in this figure. The target area enjoyed approximately 430 per cent of the normal June rainfall during the two storm occurrences.

cloud mass above the freezing level—was from the north northeast. The generating equipment was located southeast of the target area. As the silver iodide particles progressed upward from ground level to the clouds, their trajectory carried them to a position north northeast of the target. As the crystals developed in the wind flow from the north northeast during their growth stage they drifted south southwestward toward the target. A maximum number of crystals attained snowflake size and fell out of the air stream in the target area. There was a gradual reduction in this activity as the air stream moved south southwestward. This explanation appeared to be the most logical one for the shape of the rainfall pattern. During this operation, more than 200 per cent of normal June rainfall fell in the immediate vicinity of the target.

Figure 9 integrates the rainfall patterns of Fig. 7 and 8 and thus illustrates the net effect of the two operations. This pattern is so compact and decisive that it eliminates almost entirely the possibility of occurrence by chance. The target area enjoyed approximately 430 per cent of the normal June rainfall during the two storm occurrences. Inasmuch as the normal is approximately ½ in. for this portion of eastern Washington, the total rainfall amounted to more than 2 in. As this operation came at a very critical time in the growth cycle of the wheat plant, many regarded the benefits as spectacular. As mentioned previously, the official crop estimates for the area on June 1 were approximately 7 to 8 bu per acre. The final harvest yielded approximately 20 bu per acre. Some plots yielded as high as 27 bu per acre. The target area covered approximately 100,000 acres. Assuming that one-half of the land lay fallow, some estimate of the value of this operation can be derived from a consideration of the yield from 50,000 acres. If approximately 10 bu per acre is assumed to be the net gain in yield from the operation, and if wheat is worth approximately $2.00 per bushel, this experimental program during a one-week period was worth approximately a million dollars to the sponsors.

Subsequent operations in the succeeding two growing seasons have confirmed that the order of magnitude of

increased yields from cloud-seeding operations is approximately 10 bu per acre in a near normal rainfall year. In spite of the increased costs for annual operations, a benefits-to-costs ratio of approximately 100 to 1 has been conserved in this area, assuming the author's figures on increased yields to be correct. Evidence confirming these orders of magnitude has been assembled on the basis of results in other parts of the country. Those who claim that the results of cloud seeding as yet have no economic significance cannot be aware of these studies and, in turn, have provided no yardstick for the measurement of economic benefits of increased rainfall upon which to base such statements.

It should be pointed out that, inasmuch as results or benefits of cloud-seeding operations are directly related to the frequency and character of natural storm situations, it is not always possible to achieve in a short period the results illustrated in Fig. 7–9. In a sense, it may be unfortunate that the early experiments were crowned with such apparent success. This led many to expect wonders from cloud seeding even during periods of infrequent or minor storminess. Many tend to judge the benefits of cloud seeding by simply comparing annual rainfall figures with the normal. When rainfall is above normal, they are satisfied; when it is below normal, they are unhappy. Actually in neither event is cloud seeding proved or disproved, because a rainfall average or "normal" is simply the arithmetic mean of historical records. A "normal" rainfall year seldom occurs.

Dynamic Weather Types

In the final analysis, evaluation of cloud-seeding operations must be based upon some method which first explains the variability of weather and then permits a clear distinction to be drawn between induced and natural rainfall. A method of analysis which conforms to these specifications has resulted from an application of meteorological

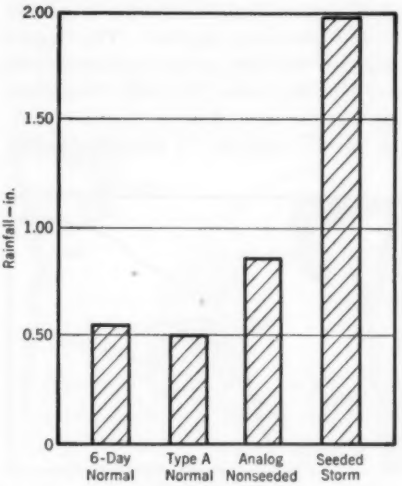

Fig. 10. Rainfall Data Evaluated by the Analog Technique

The rainfall at eight southwestern Nebraska stations for a seeded storm period, June 19–24, 1951, is compared to the rainfall at the same stations during an analog storm interval, June 10–15, 1948. The six-day normal represents the normal for any six-day period in June and Type A normal represents the normal rainfall during the occurrence of a Type A storm in June.

researches conducted by the author and his associates at the California Institute of Technology before and during World War II (10). These researches involved the classification of historical daily weather charts, depicting the broad controlling air flow patterns in the atmosphere as dynamic weather types or processes, usually running their course in approximately six days

at a given location. By classifying and cataloging the weather of record for a period of approximately 50 years by this method, it is possible to select from current weather charts similar or analogous situations in past history. The degree of similarity depends primarily upon the similarity of the sequences of weather events leading up to each analog and its counterpart in the current weather sequence. If a perfect analog could be found, all features, including the precipitation patterns, would be identical to the matching current weather situation. Thus, by comparing the rainfall patterns of a seeded situation to those of the unseeded analogs of past weather history, the analyst has a means of determining the increment of rainfall resulting from a cloud-seeding operation.

It is not possible to find a perfect analog, but the similarities that can be achieved are sometimes remarkable. Thus, the precipitation patterns for truly similar weather types in the historical record show a relatively small degree of variability—generally much smaller than the increments in the rainfall pattern that can be produced by cloud seeding. Consequently, this method of crediting rainfall to a cloud-seeding operation is proving useful. Furthermore, it eliminates the principal defect in the method which compares rainfall in target and control areas (11). The latter method fails many times because there is rarely a sufficiently high correlation between the historical records of rainfall between a target and a control area. Inasmuch as rainfall data evaluated by the analog technique refer only to the target area, correlations between a target and a control area are no longer of interest. As the number of analog evaluations increases, the probability that the results are accidental diminishes.

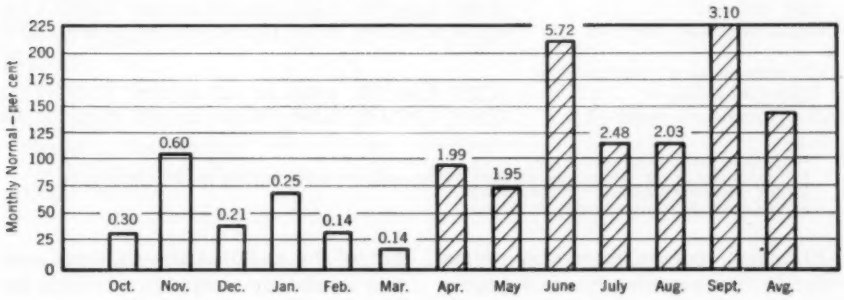

Fig. 11. Rainfall for Seeded and Nonseeded Periods

The shaded bars represent rainfall that occurred during the cloud-seeding period from April 15 to Sept. 30, 1951. The values above the bars represent the average rainfall in inches. The average bar represents the average for the seeded period.

Figure 10 illustrates a case study using the analog technique. The purpose of this study was to compare rainfall at eight southwestern Nebraska stations in a project area for a seeded storm period, June 19–24, 1951, with the rainfall at the same stations during an analogous storm interval, June 10–15, 1948. The storm during the analog period, of course, was not seeded. Such a storm is designated as a Type A storm (12); in both 1948 and 1951 a Type A storm influenced the target area for an interval of approximately six days.

TABLE 1

Increase in Crop Yield by 50 Per Cent Increase in Precipitation

	Corn	Winter Wheat	Spring Wheat	Oats	Barley	Wild Hay*	Alfalfa Hay*
Yield increase per acre—*bu*							
April–July 1951	2.96	4.23	1.69	5.50	4.23	0.1058	0.2919
Aug. 1950–July 1951	4.82	7.23	3.21	8.83	8.03	0.1124	0.3694
Harvested 1950†—*acres*							
Banner Co., Neb.	3,070	65,240	490	7,700	3,590	8,210	1,310
Cheyenne Co., Neb.	4,470	217,610	390	10,980	11,990	3,500	2,090
Deuel Co., Neb.	2,320	87,690	70	2,710	2,120	960	1,690
Kimball Co., Neb.	1,390	141,020	1,700	5,920	9,040	2,880	910
Total	11,250	511,560	2,650	27,310	26,740	15,550	6,000
Avg. price per bu, 1950—$	1.40	2.00	1.95	.75	1.05	15.00	15.00
Yield increase in all counties April–July 1951—*bu*	33,300	2,163,899	4,478	150,205	113,110	1,645	1,751
Value of increased yield‡—$	46,620	4,327,798	8,733	112,654	118,766	24,678	26,271
Yield increase in all counties Aug. 1950–July 1951—*bu*	54,225	3,698,579	8,506	241,147	214,722	1,748	2,216
Value of increased yield§—$	75,915	7,397,158	16,588	180,860	225,458	26,217	33,246

* Values for hay are expressed in tons.
† As much land in this area is fallowed, there will be additional gains from the preyield precipitation.
‡ Total return by increased yield—$4,665,520.
§ Total return by increased yield—$7,955,442.

This storm type produces near normal rainfall in southwestern Nebraska. For this reason, the rainfall figures are approximately the same for the two bars on the left of the diagram, the first bar representing the normal for any six-day period in June, or one-fifth of the average rainfall for the month of June at the stations under consideration, and the second bar representing the normal rainfall during the occurrence of a Type A storm in June. Under both normal and Type A storm conditions, the rainfall is approximately $\frac{1}{2}$ in. The third bar represents the rainfall during the interval June 10–15, 1948, during the analog or unseeded situation under consideration. The average rainfall at the stations used in the study was approximately $\frac{4}{5}$ in., or somewhat more than the average rainfall for a Type A storm. This above-normal value can be accounted for by the fact that the moisture content in the air stream from which the rain fell was higher than that usually associated with a Type A storm.

The fourth bar in Fig. 10 represents the average of the rainfall at the eight stations within the project area during the seeded Type A situation, June 19–24, 1951. Inasmuch as the amount of rain recorded during this operation is more than double that which occurred naturally in the analogous situation of 1948, it is reasonable to believe that a good portion of this increment must be credited to the effectiveness of the cloud-seeding operation. This assumption is further substantiated by a consideration of the water vapor content of the two air streams, seeded and unseeded. The water vapor content measured at the 700-millibar pressure level, which is close to the freezing level in the atmosphere,

TABLE 2

Snow Cover Measurements in Southern Utah

Drainage Basin and Snow Course	Years of Record	Water Content—*in.*			
		Past Record			Current
		Avg.	Feb. 1, 1950	Feb. 1, 1951	Feb. 1, 1952
Sevier River					
Widtsoe-Escalante Summit	14	5.3	3.8	0.9	8.6
Harris Flat Ranger Station	6	5.6			14.2
Duck Creek Ranger Station	8	8.5		2.2	21.9
Cedar Breaks	7	12.0		4.3	25.2
Big Flat	2	8.7		9.3	18.7
Beaver River					
Merchant's Valley	3	6.6		3.4	9.4
Otter Lake	3	9.2		5.7	14.9
Coal Creek					
Cedar Breaks	7	12.0		4.3	25.2
Price River					
Indian Canyon	16	6.3	13.5	5.0	16.0
Staley Ranch	10	5.1	7.9	4.7	12.8
Virgin River					
Gravel Springs Junction	2	¹ 4.8			10.3
Harris Flat Ranger Station	6	¹ 5.6			14.2
Cedar Breaks	7	12.0		4.3	25.2

was approximately 5.8 g per kilogram of air in the analog or unseeded storm, and only 3.6 g per kilogram in the seeded storm of 1951. Thus, it is felt that the appraisal of results from this study is conservative, as the analog had a greater chance of producing natural precipitation than the seeded storm.

Figure 11 gives the rainfall, expressed as a percentage of normal for each month, during the six months preceding the cloud-seeding operation and during the six months of active operations in 1951. Before the cloud-seeding operation, the rainfall was well below normal, except for one month, whereas during the operation the average was considerably above normal. This relationship, in itself, is not indicative of the success or failure of the cloud-seeding operation but is suggestive of a definite change in the rainfall pattern before and after seeding. Ultimately, the cumulative amounts of precipitation from analog studies for each individual operation will form the basis for judging effects before and after seeding. For example, if the total computed rainfall during the operating period—that is, the rainfall sum for the analogs used in analyzing each seeding operation—amounts to 20 in., and the total rainfall measured during the seeding operation amounts to 30 in., the project would have enjoyed a 50 per cent increase in natural precipitation as a result of the weather modification program.

Monetary Value

In determining the value of water to a project, the worth of crops grown in the area and the relationships between weather and yields must be considered. Table 1 illustrates computa-

TABLE 3

Comparison of April 1 Average and February 1952 Snow Cover

Drainage Basin and Snow Course	Years of Record	Water Content—*in.*		
		Avg. April 1	Feb. 1, 1952	Feb. 1 Meas. as per cent of April 1 Avg.
Sevier River				
Gooseberry Reservoir	24	18.8	27.8	148
Mammoth Ranger Station—Cottonwood Cr.	23	20.1	28.8	143
Huntington-Horseshoe	22	24.2	31.1	128
Widtsoe-Escalante	20	8.6	8.6	100
Panguitch Lake	17	6.5	7.8	120
Gravel Springs Junction	15	5.3	10.3	195
Harris Flat Ranger Station	21	9.4	14.2	151
Duck Creek Ranger Station	17	16.6	21.9	132
Cedar Breaks	17	24.6	25.2	102
Big Flat (Adjacent Drainage)	16	20.3	18.7	92
Beaver River				
Merchant's Valley	21	10.9	9.4	86
Otter Lake	16	16.8	14.9	89
Big Flat	16	20.3	18.7	92
Coal Creek				
Cedar Breaks	17	24.6	25.2	102
Webster Flat	25	17.1	22.2	130
Price River				
Indian Canyon	22	10.0	16.0	160
Gooseberry Reservoir	24	18.8	27.8	148
Mammoth Ranger Station—Cottonwood Cr.	23	20.1	28.8	143
Staley Ranch	16	6.4	12.8	200
Dry Valley Divide	17	10.2	16.4	161
Huntington-Horseshoe	22	24.2	31.1	128
Scofield Dam	3	12.7	16.7	131
Mud Creek	3	17.4	27.8	160
San Rafael River				
Huntington-Horseshoe	22	24.2	31.1	128
Virgin River				
Gravel Springs Junction	15	5.3	10.3	195
Harris Flat Ranger Station	21	9.4	14.2	151
Duck Creek Ranger Station (Adjacent Drainage)	17	16.6	21.9	132
Cedar Breaks	17	24.6	25.2	102
Webster Flat	25	17.1	22.2	130

tions of this type for the project under consideration in the storm study illustrated in Fig. 10 (13). Assuming that the net gain in precipitation was 50 per cent, Table 1 shows that the value of the operation to the farmers supporting it was $7,000,000. The cost of the project was less than 1 per cent of this amount. Thus, it is easy to understand why farmers and ranchers in the western United States have decided to support cloud-seeding operations for a long period of time to evaluate properly the potentialities. The

gamble is small and the possible benefits are large. For this reason, many present contractual arrangements with cloud-seeding operators cover a long period, some up to five and ten years.

Snowpack Increasing

Of particular interest to water users in the western United States are weather modification operations to increase snowpack. The author's organization conducted such operations during the full snowpack season in the upper Arkansas River Basin of Colorado in the winter of 1950–51 and 1951–52, and throughout southern Utah, southern Colorado, and northern New Mexico during the winter of 1951–52. The first snowpack operations began in the upper Arkansas River Basin on Nov. 1, 1950. The ratio of precipitation within the target area to adjacent regions ran as high as ten to one. It is reasonable to assume that a portion of this target area precipitation resulted from the cloud-seeding operations. Inasmuch as the winter of 1950–51 in most of the western United States was characterized by extreme drought and, thus, by precipitation far below normal, these early results of the snowpack project were encouraging. As the season progressed, the condition of the snowpack in the upper Arkansas River Basin and immediately downwind from the operation in the South Platte River Basin seemed remarkable in that it stood at a record on Mar. 1, 1951.

In the snowpack season of 1951–52 in the same river basin and in other snowpack projects, all-time records were again shattered. Conditions in the snow survey courses of southern Utah on Feb. 1, 1952, were actually considerably better than those at the end of the snowpack season, April 1, in a normal year. Table 2 gives snow cover data for southern Utah on Feb. 1, and Table 3 compares the snow cover of February 1952 with April 1 averages. A weather analog analysis of the cloud-seeding program for southern Utah from its inception on Apr. 1, 1951, through January 1952 indicated approximately a 41 per cent increase over natural precipitation for the entire period. Greatest increases were achieved during the snowpack operation which began with early snows of September and October 1951.

The same general characteristics were observed in all sectors of the organization's snowpack operations during the winter of 1951–52. It is believed that these operations materially improved surface and ground water runoff during the spring and summer of 1952 in all of the watersheds affected. This conclusion appears to be substantiated by water storage figures reported by *Water Resources Review* (14):

> The runoff of the Colorado River at Grand Canyon was the highest of 30 years of record, but far below the flood of 1921. . . . Reservoirs in Colorado that depend on snow melt are all in excellent shape, mostly full. . . . Most of the streams in Utah during snow-melt season had relative high discharge over a long period without appreciable flooding except for record floods on the Duchesne and Jordan rivers. . . . In Nevada, snow melt proceeded gradually without flooding and nearly all reservoirs are at or near capacity. . . . Runoff in New Mexico was excessive but below what had been expected from the heavy snow cover. Storage in Elephant Butte and Caballo reservoirs was more than double that of a year ago, but still only 53 per cent of average.

Legislative Problems

Until such time as operational analyses provide adequate and undeniable

proof of limitations and potentialities of cloud seeding, there will be those who clamor for various types of state or federal legislation for control of weather modification operations, in spite of the present lack of definition of the problem. During this experimental period, it is necessary to collect sufficient quantities of field data for analysis and evaluation so that legislators may be properly equipped to formulate appropriate laws. The futility of developing regulatory legislation

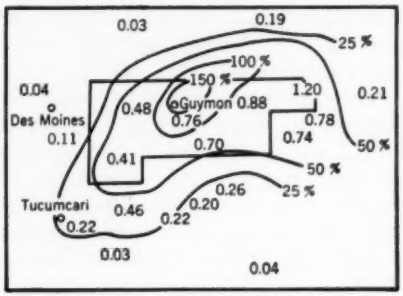

Fig. 12. Cloud-Seeded Storm of March 9–11, 1952, Over Target OT–1

The rainfall at the various cities in the target area is expressed in inches and the rainfall pattern is shown by lines joining points of equal precipitation expressed as tentative percentages of the normal rainfall.

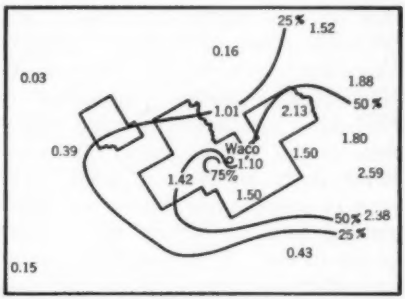

Fig. 13. Cloud-Seeded Storm of March 9–11, 1952, Over Target T–5

The rainfall at the various cities in the target area is expressed in inches and the rainfall pattern is shown by lines joining points of equal precipitation expressed as tentative percentages of the normal rainfall.

during this interval has been conceded by both federal and state legislative bodies. The necessity for keeping track of what is going on has been recognized, however, and laws have been enacted requiring the licensing of the operators and the submission of complete operating reports by a number of states, and the federal government is reviewing a bill establishing a body of experts to appraise results of the current weather modification experiments for the purpose of ultimately recommending appropriate legislation.

The National Weather Improvement Assn., the membership of which is composed of many farm and ranch groups supporting weather modification work in the United States, is also making an effort to evaluate properly these operations. That association has established an operational analysis program under the technical direction of Joseph Kaplan of the University of California. It is the intent of the group to assist universities and colleges throughout the country in developing independent evaluations of local projects. Operators are cooperating by providing complete data on field work.

Local Effects

Some experimenters claim that federal legislation is necessary to control cloud-seeding operations because of possible large-scale effects upon climate and weather (15). At present there is no information to substantiate

such claims. On the contrary, all evidence to date indicates that effects of cloud-seeding operations in the United States are restricted to local project areas. This conclusion is borne out by Fig. 12 and 13 which illustrate the effects of cloud seeding in two widely separated project areas during the passage of a single storm influencing both operating sectors. These figures show rainfall patterns in two target areas, expressed both in inches and percentages of normal for the month of March

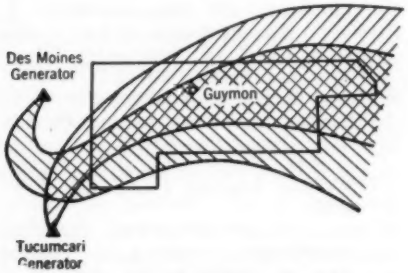

Fig. 14. Combined Plume Analysis for Two Generators Over Target OT–1

The Tucumcari, N.M., generator was turned on at 12 noon March 9 and was turned off at 8 PM, *March 9. The Des Moines, Iowa, generator was turned on at 7* PM, *March 9, and was turned off at 11:05* AM, *March 10.*

1952. Both patterns show that the rainfall maximum was centered within the project area. Figures 14 and 15 show trajectories of the silver iodide vapor plumes from the generators operating for the two target areas, based upon a computation of upper wind speed and direction, and turbulent diffusion and convective motions in the air streams. It is interesting to note that the maximum in the rainfall pattern in both operations occurred in the region where the plumes intersect. Studies of this type illustrate the operator's capabilities in localizing the effects to his target areas and also assist him in perfecting operational procedures. In both operations there were peripheral sectors in the target area unaffected by the silver iodide smoke plumes. It is believed that this accounts for the fact that such areas were not completely covered by the rainfall maximum. These are operational errors which were corrected in subsequent experiments.

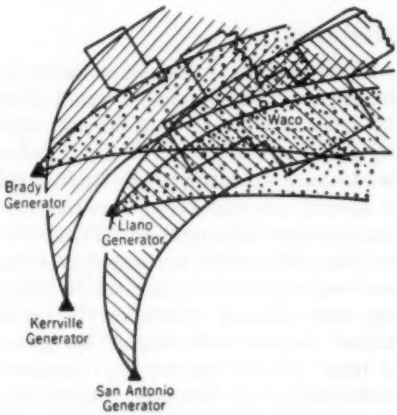

Fig. 15. Combined Plume Analysis for Four Generators Over Target T–5

The Brady, and Llano, Tex., generators were turned on at 6:05 AM *and turned off at 12:10* PM *March 10, and the Kerrville and San Antonio, Tex., generators were turned on at 11:20* AM *on March 9 and turned off at 7:00* AM *March 10.*

Further evidence that cloud seeding, as now practiced in the United States, is not producing widespread changes in the weather patterns is afforded by a comparison of the weather situation in the summer of 1952 with that during the summer of 1951. After the Kansas floods of 1951, it was suggested that cloud seeding in New Mexico and Colorado probably contributed to this

disaster. There were no floods in Kansas during the summer of 1952—in fact, the reverse is true—yet cloud seeding is going on extensively in the areas to the west. If there were any reason to believe that the rains in 1951 in Kansas had been influenced by cloud seeding to the west, then certainly the same phenomenon should have occurred in the summer of 1952 and to a greater degree.

Conclusion

Many people as yet are unaware of the important achievements attained in the field of weather modification during the past six years. On the other hand, those operating in this new field of science are convinced that the surface is almost unscratched. Future researches will permit seeding operations on clouds at temperatures above freezing, thus causing nature to yield still further to the technological progress of man. In all probability, weather modification will become a pushbutton affair within the next decade—as common as turning on a television set today. The ability to increase water resources in under-developed areas of the world as a means of increasing agricultural and industrial productivity can become decisive in the battle against poverty and hunger. Thus, the efforts of midwestern farmers to help perfect this new science may result in a vital and constructive approach to the solution of current world problems.

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A Survey of Service Line Installation Practices

Committee Progress Report

A committee progress report presented on May 8, 1952, at the Annual Conference, Kansas City, Mo., by Walter A. Peirce, Chairman of Committee E7S—Service Line Materials; Mgr., Racine Water Dept., Racine, Wis.

THE information presented herein is a summary of the data obtained from questionnaires returned by 210 water works utilities in the United States and 21 in Canada. No recommendations on practice are presented, but it is hoped that ideas will be submitted to the committee so that a recommended practice can be evolved. Although such a standard may not be adopted in whole by presently operating utilities, it should be a valuable guide for newly formed utilities.

Survey Method

A total of 363 questionnaires were mailed to all cities in the United States having a population greater than 30,000 and less than 1,000,000. Questionnaires were also sent to 46 Canadian cities having populations greater than 30,000.

These requests for information were carefully formulated by the committee in order to obtain a wide variety of information on practices of making taps, maintenance of services, type of curb stops and stop boxes, location of meters, and selection of tubing materials. The document, after many revisions, was drawn up in such a way that a minimum of time would be required to answer the questions. The questionnaire contained three parts: [1] vital statistics; [2] sketch of installation; and [3] service line data.

A total of 231 questionnaires, or 57 per cent of those sent, were returned and the answers tabulated. The data were tabulated primarily by groups based on population served rather than on the census basis. This type of tabulation offers a better classification because many utilities serve a larger population than is indicated by the official figures, and others do not serve the entire population. By this method the cities were classified in the following six population groups: 30,000–50,000 (group includes five serving slightly less than 30,000); 50,000–100,000; 100,000–200,000; 200,000–300,000; 300,000–500,000; and more than 500,000.

Vital Statistics

Returns were made by 30 privately owned, 11 authority or district owned, and 169 municipally owned utilities in the United States, serving a population of 34,005,105 and having 6,852,033 customer accounts. These data indicate that almost five persons (4.97) are served per active account. Canadian cities serving a population of 4,238,237 had 793,108 active accounts, or 5.35 persons per account. All Ca-

nadian utilities except that of Halifax, an authority or district owned utility, were reported as municipally owned.

Service Line Data

Unless otherwise mentioned, the service line data apply to the United States as information is still being received from Canada. A total of 139 utilities, or 66 per cent of those reporting, installed the services. Of these, 26, or 19 per cent, charged the service to the property. Of 89 cities reporting, 74 maintained service from main to curb or property line and in 15 the customer maintained this portion. Of 104 cities reporting, 23 carried maintenance all the way to the meter and in 81 the customer maintained the service line from the curb to the meter. Secondary or submeters are owned by the utility in 87 cities, and by the customer in 111, of a total of 198 reporting. Tapping data are given in Table 1.

The use of multiple taps for 1¼-, 1½-, and 2-in. services is of interest. It appears to be a practice that is not favored so much since the use of copper instead of lead has increased. Many utilities make use of tapping sleeves and valves or pipe saddles. Data on types of joints, goosenecks, curb stops, curb boxes, and meter settings are given in Table 2.

Materials

The committee listed six materials—copper, brass, wrought iron, steel, galvanized iron, and lead in the questionnaire. Various utilities use different combinations of these six or approve their use. The hardships caused by copper restriction are apparent, inasmuch as 51 per cent of the utilities use only copper tubing and another 40 per cent list copper as one of the materials.

TABLE 1

Tapping Data

Item	No. of Utilities Using	Per Cent of 210 Returns
Tap on top of main	39	19
Tap on side of main	57	27
Tap at 45 deg with horizontal	113	54
Tap at other angle	13	6
Tap at more than one position	11	5
Horizontal offset on side taps	58	28
Tap size same as service	162	77
Tap smaller than service	12	6
Tapping thread used*		
AWWA (Mueller)	200	95
Standard pipe (ASA B2.1)	20	9
Other	3	11
Saddles used for taps	119	57

* Percentages total more than 100 because some utilities use more than one thread.

TABLE 2

Joints, Goosenecks, Stops, and Meter Settings

Item	No. of Utilities Using	Per Cent of 210 Total Returns*
Lead joints flared	39	19
Lead joints wiped	47	22
Copper joints flared	177	84
Copper joints sweated	31	15
Gooseneck not used	15	7
Gooseneck smaller than service	13	6
Regular ground key stop	102	49
Inverted ground key stop	86	41
Stop and waste	12	6
Stop box		
Buffalo type*	100	73
Minneapolis type,† screwed to stop	24	18
Minneapolis type,‡ arch style	13	9
Rod in box	46	
Blocking under stop	89	
Meter set inside building	129	
Meter set outside building	118	
Either inside or outside	37	
Inside meters set above floor	123	93
Inside meters set below floor	9	7
Meter yoke used	49	

* Except those percentages in brackets.

† The Buffalo box is all cast iron and has cast coarse threads for adjusting the height.

‡ The Minneapolis type box has an upper section of steel pipe which is adjustable for height by sliding up or down in a lower cast-iron section. In one style the lower section is screwed to the curb stop. In the arch style the lower section consists of an inverted U which straddles the service line.

Table 3 gives a classification of cities using the various tubings.

Thus far the committee has not stud-

ied new service line materials, such as plastics, aluminum, and terne-plated steel. There is probably a field for some of these materials but no utilities mentioned their use. Ottawa, Ont., referred to steelclad copper.

TABLE 3

Water Service Tubing

Material	Cities by 1,000 Pop. Served						Total Returns	Per Cent of Total Returns
	30–50	50–100	100–200	200–300	300–500	Over 500		
No. of Returns	57	61	41	17	20	14	210	
Copper	29	35	16	9	13	4	106	51
Copper and lead	7	7	7	2	2	5	30	14
Copper and galvanized iron	9	7	5	1	1	1	24	11
Galvanized iron	2	4	4			1	11	5
Lead		3	1	1		1	6	3
Wrought iron		2	1	1			4	2
Copper, lead, and galvanized wrought iron		4	1				5	2
Copper, brass, and lead	2		1		1	1	5	2
Brass	1		1				2	1
Copper, brass, and galvanized iron				2			2	1
Copper, brass, galvanized iron, and lead	1		1		1		3	1
Lead and galvanized iron	1		1	1			3	1
Copper, brass, wrought iron, galvanized iron, steel, and lead	3						3	1
Copper, wrought iron, steel, and galvanized iron		1				1	2	1
Copper, brass, and wrought iron			3				3	1
Copper and brass				1			1	0.5
Copper and cement-lined wrought iron	1						1	0.5
Copper (cement-lined wrought iron alternate)					1		1	0.5
Copper and wrought iron	1						1	0.5
Copper, galvanized iron, and lead	1						1	0.5
Copper, wrought iron, galvanized iron, and lead				1			1	0.5
Copper, brass, and lead					1		1	0.5
Copper, wrought iron, and lead						1	1	0.5

Water Supply Problems of a Fast Growing Community

By Robert Enzweiler

A paper presented on Mar. 27, 1952, at the Illinois Section Meeting, Chicago, by Robert Enzweiler, Staff Utility Engr., Park Forest Water Co., Park Forest, Ill.

MOST organized communities, of whatever size, seem just to appear. They grow according to the whims of man and circumstance. They evolve. The best the water works engineer can do, from time to time, is hope he can predict the course of that evolution, and hope for some pattern he can count on.

Park Forest, Ill., erupted. But like the explosion in the cylinder of an automobile, the explosion was closely controlled and well calculated in its effects. This may seem to place the Park Forest water works engineer in an enviable position. In many ways it does, but it, too, has its headaches and its hazards.

The problems of the Park Forest Water Co. at the outset were by no means typical. Park Forest was not intended as another housing project capitalizing on existing utility, business, and cultural organizations, nor could it have been. There was no adequate business center, schools, or churches in easy distance, and there was no ready-made water supply.

To men of lesser imagination than the staff that first visited the site, a self-sufficient community might have seemed inconceivable. There was only a golf course and a prairie at the remotest southern point of Cook County. Water was hard come by, and once obtained it was even harder. The men taking this calculated risk were developers, not building contractors. An elementary fact of life for developers is a safe, potable water supply. There was no alternative but to make one at Park Forest.

The Park Forest Water Co. was fortunate at the time in having a most competent staff engineer, the late Charles Waldman, to whom goes much of the credit for early development of a water installation, a development which has been adequate, so far, for the growth of Park Forest. One of the professional water supplier's biggest problems is the adequacy of his installation under scattered and unpredictable conditions of growth.

Since the inception of Park Forest, the water company has been able to anticipate growth by adjusting both the rate and final limit. Park Forest is a planned community in the best sense of that adjective; it is a community integrated in terms of its final population and physical growth. Because of this community integration, the water department has been able to phase the increments of plant expansion both in the present and future.

Construction Phases

The first phase of operation was an installation to serve 12,000 consumers in 3,010 rental units. This operation included softening and filtering facilities extensive enough to accommodate all of the first construction phase.

The second phase, in which the company is now engaged, is an exact duplication of the first to service 2,800 private homes which are now being sold at a record-breaking rate for the Chicago area.

The third and final development will be the accommodation of 2,500 more private homes and a population expected to reach approximately 30,000 by the end of 1954. Again, the water company will simply duplicate the initial installation.

Source of Water

Park Forest water is drawn from three wells. The three are similar in physical characteristics and water analysis. Each well is drilled to a depth of 300 ft and terminates in Silurian dolomites. The water obtained is nearly identical in temperature and mineral content. Without softening, the exceptional natural hardness of the water—610 ppm—would make it unsatisfactory for water heating units and would occasion excessive soap consumption for laundering and personal hygiene, strong indications of the need for softening equipment.

The first well was drilled very early in the project when plans were fluctuating almost daily. The well was no sooner drilled than it was decided by the town planners to shift the first phase of construction half a mile away from the original site. The first well was temporarily capped and a second well was drilled at the opposite side of the site. Inasmuch as they were surrounded with wells, the planners selected a site midway between the two wells and started to build.

Installations

The first construction phase of 3,010 rental homes was started in October 1947 and completed in September 1949. This development required 13 miles of bell-and-spigot, cast-iron main from 6 to 16 in. in diameter, and valves and hydrants.

Next in importance was the softening plant which was started in January and completed in November 1949. The softening process may be described as an upflow, continuous type, lime–soda ash, alum system of 1.2-mgd capacity.

The second construction phase was started in May 1950 and completed with water mains for 2,500 private homes by November 1950. The Park Forest Water Co. laid 20 miles of main, 6 to 16 in., and supplied valves and hydrants to serve a total of 5,510 dwelling units. A 500,000-gal elevated tank was completed in December 1950.

In the first construction phase, 13 miles of bell-and-spigot pipe was installed at the rate of 300–500 ft per day per crew. Some difficulty was encountered in sterilizing the main. In the second construction phase, 20 miles of main with mechanical joints was installed at the rate of 1,200–1,500 ft per day per crew. No difficulty in sterilizing was encountered.

The softening plant was in operation only six months and the staff barely trained when the soda ash strike put it out of business. For six months Park Forest drank hard water. Later, because of mechanical difficulties with sulfuric acid feeding, the water depart-

ment changed to carbon dioxide which was delivered as a liquid in bulk truck loads. Carbon dioxide proved to be a better product at some decrease in overall cost.

The Park Forest Water Co. is now in its third construction phase which will entail duplication of initial plant and the laying of water main for another 2,500 private homes. Approximately 1,000 of these homes will be cooperative row structures presenting problems similar to those encountered in the rental homes. The third construction phase is expected to be completed late in 1952.

Fluoridation

During recent weeks the water company has been working on plans to fluoridate Park Forest water. Tentative plans include the addition of the standard 1 ppm fluorine through an automatic feeder. Fluoridation is being incorporated in response to a rather strong public demand. The Park Forest Water Co. expects to be the first private water company in Illinois to undertake fluoridation.

Taste of Water

Only one public relations problem has arisen—the taste of the water. The consumers in Park Forest come from all parts of the world. An unusual concern was shown in what was done to the water. Some wanted it flat, some wanted it tastier. Some were accustomed to drinking hard water, others wanted it soft. Much time was spent in explaining to these people the processing and the factors for which the processing was designed. When the water had to be recarbonated to prevent pipe encrustation, one woman informed the water department that she didn't think dishes would wash so well in charged water and that drinking it might make her children sick.

Conclusion

The author feels that the Park Forest Water Co. is, in many ways, in an enviable position. The knowledge of what to expect, the fact that the staff has been trained by the water company, and the position as a private water supplier—at least for the time being—have made the task of developing the plant and distribution system somewhat easier than usual. Park Forest is a development without precedent, however. It has been as much of a challenge to the water company as the development of Park Forest has been to its builders.

Plainfield, N.J., Meter Repair Shop

By George M. Haskew

A paper presented on Oct. 26, 1951, at the New Jersey Section Meeting, Atlantic City, N.J., by George M. Haskew, Engr. & Supt., Plainfield-Union Water Co., Westfield, N.J.

A METER repair shop is a very important part of every water company's equipment. Plainfield-Union Water Co. territory is 100 per cent metered and, like most water companies, is growing rapidly. In 1948, as the old shop and equipment were overtaxed, the author designed a meter repair shop that would meet present needs and future growth for some time to come.

Construction was started in July 1948, and, after a few delays, the shop was completed in January 1949. In designing the building, the author had in mind a horseshoe. Incoming items enter at one end, go around the toe of the shoe for repairs, and then proceed to the other end for storage and use allocation.

Exterior Construction

The building, shown in Fig. 1, covers an area of 32 × 50 ft and has an extension 10 ft 4 in. by 21 ft 4 in. The extension houses the heater room and the lavatory, and makes a total of five separate rooms. The main repairing room has 840 sq ft, the receiving room 283 sq ft, and the storage and disbursing room 283 sq ft. The building has concrete foundation walls and footings. The foundation walls are carried 3 ft above grade, and the entire interior of the building is filled to this level. The floors are of reinforced concrete. Above the 3-ft foundation, 8-in cinder blocks having a 4-in. brick veneer facing are used. The brick veneer is continued over the foundation to within 18 in. of the grade line. In front of the building and 4 ft back from the front on each side a parapet wall with precast cement coping was constructed 2 ft 6 in. higher than the roof line. This parapet was built to hide the skylight and flat roof.

The roof is flat, sloping from the front to the rear of the building, and is covered with a built-up, 20-year bonded roof with zinc gravel stops and fascia board (molding) around the entire building. The roof is heavily insulated to provide a cool building.

Interior Construction

All the ceilings are 12 ft high and plastered throughout. The main repair room and lavatory have plastered walls. The remainder of the interior walls were left plain. Over the benches in the main repair room there is a skylight 8 ft square to provide ample light. The rear of the building is equipped with a loading platform 33 × 3 ft and an overhead crane for handling large meters. Access from the loading platform to the receiving

Fig. 1. The Plainfield, N.J., Meter Repair Shop

The small building at the left of the meter repair shop is a switchgear house from which the shop receives its current by underground conduit.

Fig. 2. The Main Repair Room

At the first bench, which contains a sink with hot and cold water for cleaning, the meters are dismantled and cleaned, then passed to the next bench for repairs, and then to the testing machines.

and storage room is provided by 8 × 8-ft roll-up doors for easy handling of meters and equipment.

Repair and Testing Routine

The receiving room handles all meters to be repaired or tested. The floor in this room slopes to a center drain. Frozen meters placed on the floor thaw overnight and the water is disposed of readily. From the receiving room the meters go to the main repair room (Fig. 2) for servicing. The first bench contains a sink with hot and cold water for cleaning. Here the meters are dismantled and cleaned, passed to the next bench for repairs, and then to the testing machines. After the meters are tested and the records made up, the meters are sent to the storage room. They are now ready to go into service. The floor of the repairing room likewise slopes to a center drain, thus facilitating the disposal of excess water and the washing of the floors.

Equipment

The repair room is equipped as follows: small tester * which will test five $\frac{5}{8}$-in. meters in series or singly; a large multiple tester which will test, in series, ten $\frac{5}{8}$-in. meters, seven $\frac{3}{4}$-in., four 1-in., five $\frac{3}{4}$-in., or two $1\frac{1}{2}$- or 2-in.; grinder; buffer; drill press; filing cabinets; metal desk; chair; and other miscellaneous equipment. The gear train bench and work table are equipped with compressed air and trigger valves. This equipment is used for cleaning purposes.

The entire shop is a self-contained unit having its own lavatory, heating plant, air compressor, and tank. A steam heating system is used. Electric blowers having individual thermostats are located in each room except the lavatory, which has a radiator. Thus, different temperatures can be maintained in the repair, receiving, and storage rooms.

Fluorescent lighting tubes are used throughout the interior. Fixtures are placed to give adequate light over all benches and testers for night work or very dark days. Current for the lights and machinery is taken, by underground conduit, from the switchgear house which is located across the driveway from the shop. This nearby switchgear house provides the main supply for the water plant and gives the water company the advantage of low rates.

During 1950, the following meters passed through the shop for testing and repairs: 5,420 $\frac{5}{8}$-in. meters, 38 $\frac{3}{4}$-in., 51 1-in., 14 $1\frac{1}{2}$-in., 40 2-in., 1 3-in., 6 4-in., 6 6-in., and 1 8-in., making a total of 5,577 meters tested and repaired.

The personnel consists of one working supervisor and three men. A 15-ft driveway between curbs and a large rear yard paved with blacktop facilitate easy delivery of goods and removal of meters to be installed in the system. At present there are approximately 39,500 meters in service in the Plainfield-Union Water Co. system.

* A product of the Mueller Co., Decatur, Ill., is used.

The Ridgewood, N. J., Service Building

By J. Arthur Carr

A paper presented on Oct. 26, 1951, at the New Jersey Section Meeting, Atlantic City, N.J., by J. Arthur Carr, Engr. and Supt., Dept. of Water Supply, Ridgewood, N.J.

FOR many years the facilities of the Ridgewood Dept. of Water Supply were scattered at widely separated locations. Trucks and cars were housed in the municipal garage on Chestnut St. Pipe and heavy fittings were stored at the East Glen Ave. Pumping Station. Small stock and tools and the meter shop were in an old building on Hudson St.

The Hudson St. building was also used as a garage for the village ambulance and as a storage place for the shade-tree department tools and materials. The meter shop utilized only a small portion of the second floor, which was reached by a cramped stairway, and had no facilities for handling meters larger than ¾ in. Meters larger than ¾ in. were serviced for the water department by the Passaic Valley Water Com.

The Ridgewood Dept. of Water Supply had been operating under these conditions since 1921. Since that time, however, the number of consumers increased 400 per cent and it had become practically impossible to carry on the department's work properly and efficiently. In addition, a lot of time was lost when construction and repair crews started a day's work as it was frequently necessary for trucks to visit all three locations for required equipment and material.

Naturally, as the water department grew, other departments were also growing and the municipal garage was greatly overcrowded with the additional trucks and equipment. It became necessary to enlarge the garage or move the water department equipment out of it. After carefully considering the water department's needs, which seemed the most urgent, it was decided to move water department equipment out of the garage and to provide a building large enough for the water department for many years to come.

The logical location for such a new building was at the site of the East Glen Ave. Pumping Station (Fig. 1) where there was plenty of room and where the pipe yard and warehouse were already located. Early in 1949 plans were made and the building completed. The department moved in early in 1950.

Architecture

The other buildings in the group were of pseudocolonial type with cream colored stucco finish; therefore, the same style of architecture was followed in the new structure. Design factors of permanence, future growth, low maintenance costs, ventilation, and light were given consideration. The building is U-shaped, 100 ft long, 56

ft wide on the wing sections, and 28 ft wide in the center section (Fig. 2). The foundation walls, basement floor, and first floor are poured concrete. The foundation is membrane waterproofed. The sidewalls are cinder block with a cream-colored stucco exterior finish. The roof is wood framed with heavy asphalt shingles and is insulated. All window and door frames are of steel.

Facilities

The basement consists of a boiler room, large storage room, and a smaller room eventually to be used as a machine shop. An air compressor and a gas-fired hot water heater are located in the boiler room. The first floor consists of a fully equipped laboratory, an office for the foremen, lavatory, large meter testing and repair room, meter cleaning room, and stock room for brass goods and small tools. The foremen's office is finished in knotty pine. The walls of the laboratory and meter shop are tan tile to a height of 5 ft, above which they are furred and plastered to the ceiling. Plaster walls are painted a pastel green.

The meter shop floor is truck height and is equipped with overhead access doors at both meter shop and stockroom. At the stockroom door there is a trapdoor in the floor equipped with an electric hoist so that heavy articles can easily be lowered to the basement. All sinks and drainboards in the laboratory and shop are soapstone and all drainpipes are acid-resisting pipe. There are several conveniently located steel-topped work benches. Work benches are tilted slightly to the rear and are provided with drainpipes. Each bench has several compressed air, gas, and electric outlets.

Fig. 1. The East Glen Ave. Pumping Station

The site of this station was chosen for the new service building because there was available space and because it was also the location of the pipe yard and warehouse.

Fig. 2. The New Service Building

The building is U-shaped, 100 ft long, 56 ft wide on the wing sections, and 28 ft wide in the center section.

Meter testing equipment consists of one eight-unit test machine for small meters and a single-unit test machine for meters up to and including 2 in. All piping, connections, and drains are provided for another multiple unit test machine which can readily be installed.

In the basement there is a bench grinder equipped with wire brushes for cleaning dirty meter cases and rusty bottoms. A dust collector is attached to the grinder (Fig. 3) making this operation a relatively tidy one. A roof type exhaust fan is connected by ducts

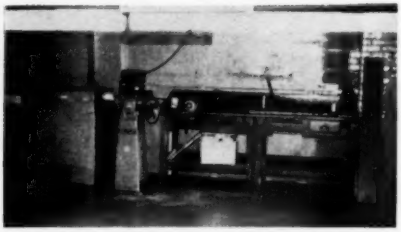

Fig. 3. Bench Grinder and Dust Collector

The bench grinder is equipped with wire brushes for cleaning dirty meter cases and rusty bottoms.

to both the laboratory and meter-cleaning room and readily removes all steam or fumes.

The water department is equipped with three-way radio. While operating on the police wave length and from the police antenna, an auxiliary transmitter and receiver in the meter shop permit the department to receive and transmit messages directly. In addition to an outside telephone, the service building is connected with the main office by a private wire. A gasoline-driven generator of sufficient capacity has been installed to provide the building with lights. This generator will also keep the radio in operation during emergencies.

A large attic space, reached by a disappearing stairway from the stockroom, is used to store records and light material which is not often in demand. The north wing of the building is used to provide garage space. At present it will house four large trucks and several pumps. The department has sufficient land to extend the garage wing to the west if and when it is necessary.

Conclusion

All water department facilities are now in one location. The meter shop is a light, airy, and pleasant place in which to work and the men are very proud of it. The author feels that these expanded facilities have added greatly to the efficiency of operation.

Industrial Water Use

By W. J. Lauterbach, M. D. Sanders, L. W. Petersen, and C. J. McLean

A panel discussion presented on Mar. 28, 1952, at the Illinois Section Meeting, Chicago, by W. J. Lauterbach, Chief Chemist, Corn Products Refining Co., Argo, Ill.; M. D. Sanders, Head, Chemical Eng. Div., Research Laboratories, and L. W. Petersen, Chemical Engr., both of Swift & Co., Chicago; and C. J. McLean, Gen. Hydraulic Engr., Public Service Co. of Northern Illinois, Chicago.

Corn Products Industry—*W. J. Lauterbach*

FUNDAMENTALLY, wet-milling corn plants are in the starch business. It is of prime importance, therefore, that the maximum amount of starch in the corn kernel be removed and recovered from the kernel. It is equally important that the starch recovered be of the highest quality possible. After recovery from the kernel, all brands of regular or modified starches can be completed as finished products. Sugars and syrups are produced by starch hydrolysis.

To perform the starch separations on a practical, high-volume basis, and yet with an efficiency which insures maximum recovery, large volumes of water are required. Clear water, with or without filtration, is not necessarily suitable water for wet milling. As a result of research and process engineering surveys, specific standards for the water used at different stages in every plant have been set up. Usually, water used in wet milling falls into one of three distinct categories: [1] water for cooling; [2] water for steam and power; and [3] water for processing.

At present an average of 40 gal of water per bushel of ground corn is used directly, and an additional 100–200 gal per bushel is used indirectly. Meters which register the total water pumped indicate that these calculations of water consumption are fairly accurate.

Before 1930 a substantial amount of the water used in the processing departments found its way to the plant sewers. Since that time, however, the "bottling-up" process has been practiced generally in all wet-milling plants. The bottling-up process has been responsible for a material recovery of the valuable solubles that are formed during steeping and has also accounted for a noticeable reduction in the volume of water consumed in processing, as a result of its economical reuse.

Testing

Inasmuch as the wet-milling industry is essentially a food industry, all water used in any of the processing departments is regularly submitted to both chemical and bacteriological examination by technical analysts. Thus, every precaution is taken to keep all raw surface waters from contaminating any water pumped from underground

wells or supplied by municipal pumping stations. Both the plant well water and the municipal supply are considered fit for drinking purposes, and, by the same token, fit for food processing.

Processing

One set of pumps and pipelines carries the raw water and another set the well water; no cross connections are tolerated. The raw water is used solely for cooling purposes on condensers and therefore need not be treated. Well water from plant wells or water received from the municipal supply is used for steam, power, and processing purposes. This water is treated by presoftening methods or zeolite sands to minimize boiler scale problems and corrosive effects on power and steam equipment, and to remove chemicals which are objectionable or which would cause trouble in finished products. To set up standard specifications for water analysis in the industry as a whole would not be practical. Each individual plant must select the kind of water to be used and set up its own specifications. Some plants have large volumes of condensate available while others may have very little. It is sometimes customary to make proportionate blends of satisfactory condensate with softened well water. This blended water is used primarily in the various washing and diluting operations. The author feels that many operators would be very happy to use 100 per cent condensate for the washing and diluting operations.

The chemical elements which are found most frequently in varying degrees in well water and which are objectionable for corn plant usage include iron, calcium, and magnesium. Efforts are made to keep these elements and their salt combinations at a minimum in the water leaving the various types of water softeners in plant operation.

As a result of the bottling-up process, the maintenance of a proper water balance, to insure continuous, 24-hr-a-day operation throughout all the departments demands careful and thorough planning. The larger the plant, the more complicated the problem becomes. The term fresh water is applicable only to water which enters the process directly from the softeners or condensate sources. Theoretically, fresh water should be used only at the end of the process and for starch washing and dilution. As the starch slurries are dewatered on vacuum filters, the filtrates begin moving countercurrently through the process and finally end up in the steeping operation at the head of the process where the corn, as received, is introduced. Water drawn off (light steepwater) is concentrated to a definite dry-solids content.

In the intermediate operations, water and starch slurries are used for lubricating purposes in the grinding mills and water is used extensively for washing starch out of the corn fibers in many different types of screening devices. When all the component parts have been thoroughly washed and recovered, they are dewatered by various types of filters or moisture expellers and enter the driers in a semi-moist state. An appreciable amount of fresh water leaves the driers as vapor and disperses into the atmosphere.

Conclusion

Every day that the author's plant is in grinding operation, 100,000 bu of corn are processed. This processing requires 3 mil gal of water pumped from

Lake Michigan by the Chicago water system, 2.5 mil gal of well water pumped from the plant's underground water supply, and approximately 20 mil gal of untreated river water. The corn products industry requires almost 7 bil gal of water annually, enough to supply a city of approximately 150,000.

Meat-Packing Industry—*M. D. Sanders and L. W. Petersen*

Water that is bacteriologically safe is taken for granted by most Americans. In large part, they owe this feeling of security from waterborne disease to the vigilance of the public health engineers in city, state, and federal services. The meat-packing industry has borrowed liberally from the information published by these workers for use in the sanitary control of its water supplies, as bacteriological purity is the first requisite of water used in the processing of meat and edible meat products.

The amount of water used in the processing of livestock for meat varies rather widely depending on its availability, the rate of kill in relation to plant size, and the complexity of by-product processing. The volume of industrial waste is a reflection of water usage. The volume of water discharged to the sewers per ton of live weight dressed has been determined and reported at a number of plants. Mohlman (1) reports industrial-waste volume from Chicago meat-packing plants to vary from 1,900 to 8,700 gal per ton of live animal slaughtered. The average usage is 4,130 gal. The U.S. Public Health Service (2) reports an average of 6,053 gal of waste per ton of live weight processed at eleven meat-packing plants in the Ohio valley. If Mohlman's average of 4,130 gal per ton is used, a medium-sized meat-packing plant processing, for example, 750,000 lb live weight per day would require a little more than 1.5 mgd of water.

Source

With perhaps minor exceptions, there are only two sources of potable water for meat-packing plants. Municipal supplies are generally used by plants in the large cities, whereas plants in country areas or small towns usually depend on deep wells. Chlorination of well supplies is practiced only to a limited extent, as potability is always adequately safeguarded at the source by proper well construction and by rigid and frequent inspections to assure the absence of cross connections with nonpotable supplies. Sampling of water at the taps for sanitary analysis in all departments of a plant processing edible products is a regular practice, both of the plant bacteriologist and the Meat Inspection Div. of the U.S. Dept. of Agriculture.

Cooling- and condensing-water requirements of a meat-packing plant may equal or exceed the plant's requirement for process water. Water requirements for refrigeration may be partly satisfied by passing the plant intake water through closed shell and tube ammonia condensers before it enters the plant mains. Water from wells may discharge first through these heat exchangers into a protected reservoir from which it will be pumped into the plant water system. A reservoir of proper size can thus accumulate the water passing through the ammonia condensers overnight for a reserve to help provide for the heavy drafts of water during the day.

Sometimes cooling water is supplied from surface sources, such as rivers, lakes, or open spray ponds. Such nonpotable supplies are, of course, rigidly separated from potable supplies, and any makeup from potable supplies comes through an air gap of approved construction.

Treatment

Although not of such great importance as bacteriological purity, the mineral characteristics of water supplies in meat-packing plants often necessitate some treatment for use in certain processes and equipment.

Boiler feedwater treatment follows the usual practice for low- and medium-pressure boilers. Hot lime-soda treatment, cold lime-soda with sludge blanket precipitation, or ion-exchange treatment, all followed by phosphates to produce a soluble residual in the boiler, are common in hard-water regions. As boiler pressures rarely exceed 275 psi, however, many meat-packing plants omit treatment of boiler feed except for deaerating. Instead they employ internal conditioning with alkalies, phosphates, and organics, such as starch, tannin, and alginates.

Since the approval by the U.S. Public Health Service (3) of the controlled use, in amounts not exceeding 10 ppm, of molecularly dehydrated phosphate as an additive to potable water, it has become possible to ameliorate several annoying characteristics of certain waters. The ferrous iron content of deep well waters, for example, which normally precipitates to the red ferric form on aeration, is often prevented from doing so by the addition of a few parts per million of a polyphosphate at the well head (4). Deposition of scale is prevented, or reduced, in hot-water heaters (5) by the same treatment. A meat-packing plant may use approximately 20 per cent of its potable water consumption for cleaning, at a temperature of 180 F; thus, the importance of scale prevention in hot-water heaters is apparent.

Deep well supplies are occasionally infected with *Crenothrix* or other iron-oxidizing bacteria. There is some evidence (6) that controlled threshold treatment of the water with polyphosphates will minimize these growths, presumably by reducing the availability of soluble iron to the bacteria. Sterilization of plant distribution systems with high chlorine concentrations or with live steam will obviously remove the growths with which they come into contact, but, if the iron-consuming organisms are in the well itself, sequestering with dehydrated phosphates seems to be the only recourse, aside from precipitation and filtration.

Aggressive waters, both from deep wells and some municipal supplies, create red-water problems and deteriorate pipelines. Sometimes these conditions are controlled by pH adjustment to shift the equilibrium to slight scale deposition. One satisfactory treatment for a soft aggressive water included the proportional addition of caustic soda to the mains in sufficient quantity to shift the Langelier Index to a slightly scale-forming pH, followed by the controlled addition of 2–3 ppm of molecularly dehydrated phosphate. This treatment has also been combined with the proportional addition of chlorine to satisfy a demand developed by approximately 1 ppm of sulfide. Both treatments reduced discoloration of the water and corrosion to tolerable levels. To provide a reasonably prompt check on the effectiveness of such treatment, weighed coupons of carbon steel are often installed in the water lines. Re-

moval and examination after a few months gives an immediate measure of the degree of corrosion control.

Control of growths impeding heat transfer on heat-exchange surfaces must be coordinated with the end use of the water. If potable water is being used on closed condensers, to be pumped later into plant mains, controlled chlorination is the only practical treatment permissible. If a secondary water supply not connected with potable lines is used for condensing purposes, however, it may be slugged with chlorine, copper sulfate, or other algicides and fungicides.

An interesting phenomenon developed in a nonpotable, recirculating cooling water supply several years ago. Active corrosion of steel occurred from an apparently passive water. Exhaustive examination finally revealed a high nitrate content in the water. Ammonia picked up by the system from slight leaks in condensers was apparently being oxidized to nitric acid by bacterial action. Review of the literature revealed a similar incident in an ammonia condensing system (7). Maintenance of a higher pH by the addition of alkali did not, of course, stop the formation of nitric acid, but did control the rate of corrosion. Chlorine was also added, but it could not be determined if nitrate production was completely stopped.

Summary

1. The potability of the water used in food-processing departments must be beyond question.

2. The mineral characteristics of the water can usually be altered to fit the conditions imposed by the specific water usage by relatively simple and safe application of harmless additives.

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Electric Utility Industry—*C. J. McLean*

There are many water problems in the electric utility industry. These problems, of course, vary in magnitude and frequency. Some utilities in areas deficient in water supplies are plagued by lack of water, while others have problems with the quality of water. In the Kansas City flood in 1951 the utilities, as well as other businesses, suffered from too much water. Some think that water problems in the electric utility industry occur primarily in hydroelectric plants. There are a few small hydroelectric plants in Illinois at which some water problems do occur, but Illinois actually has very little hydroelectric power, because the topography of the state does not make it possible to develop power by this means in substantial

quantities. Of the power generated on the Commonwealth Edison–Public Service System in 1951, less than 0.4 per cent was produced in a hydroelectric plant. Water problems in this part of the electric utility business are not a vital factor, therefore, in maintaining service to customers. Water problems do occur, however, in the steam turbine generating stations.

Few people realize the large part water plays in the electric utility industry. From the very beginning of the planning for a large fuel-burning generating station, water must be a dominant consideration. The station must be located adjacent to an adequate supply of condensing water. No other site, however desirable otherwise, will do unless a cooling-tower installation is used. Such installations are common in the Southwest but are not used in Illinois because they are not as economical as adequate cooling-water supplies. Markets, of course, are important. If the site can be close to a market, so much the better, but transmission lines can be used. An adequate fuel supply is, likewise, a prime consideration, but coal can be transported. Inasmuch as the water required for condensing purposes weighs 600 times as much as the coal burned in the boilers, it is understandable why water is a major factor in the electric utility industry. A large part of the equipment in the station utilizes water in some form. This equipment includes pumps, boilers, condensers, water treatment plants, water storage tanks, screens for removing trash, chlorinators for algae control, and the many showers and locker rooms necessary for the personnel required to operate these modern generating stations.

Condensing Water

Modern, high-temperature, high-pressure boilers are capable of evaporating large volumes of water. Steam is delivered to the turbines at temperatures which may be as high as 1,050 F and at pressures up to 1,800 psi or more. After passing through the turbine, this steam must be condensed quickly to water again in huge condensers which produce vacuums with pressures of 29 in. of mercury. A 150,000-kw generator requires more than 1,000,000 lb of steam per hour; the volume of water delivered by the circulating water pumps for condensing the steam for such a unit is approximately 150,000 gpm or 216 mgd. In the Edison system on a peak summer day, approximately 2,800,000 kw are being used. The generating units vary in size, age, and efficiency, but during the high load period the total volume of condensing water may be pumped at the rate of 3,000,000 gpm, or more than 4 bil gal per day.

Where, it may be asked, is such a volume of water available? The answer is simple: the water is not consumed but is returned to its source immediately and, therefore, is used several times, not only by the utility industry, but by others who make a similar use of the stream as a source of cooling water.

The Waukegan and State Line generating stations located on the shores of Lake Michigan have a plentiful supply of clean, cool water at their intakes. The problem at these stations was to locate the intake and discharge channels so that a minimum of recirculation of the warmed condenser water would result. In the winter, however, a reuse of some of the discharge water

helps to solve the problem of ice which clogs the trash racks and screens and, at times, would almost completely shut off the supply of condensing water. On at least one occasion, shore ice was packed so tightly by a northeast wind that the water had difficulty in getting back to the lake. Only a fortunate change in wind direction saved the day. The problems encountered at the Waukegan and State Line generating stations are similar to those encountered by Chicago and other shoreline communities that pump water from Lake Michigan. The stations are fortunate, however, in having warm water available to help melt ice, an advantage the Chicago and shoreline communities do not have.

The stations in Chicago on the Chicago and Calumet Rivers have problems that are peculiar to these streams. Nature designed them to flow into Lake Michigan. Man has reversed their natural course and, consequently, the discharge channels from the stations are located in a position that would normally be upstream from the intake. The flow into the Illinois Waterway normally maintains a current past these stations and the water is used and reused several times as it moves westward through the city. Any situation that reverses this direction of flow for an extended period produces problems in plant operation because of the rise in temperature of the cooling water. Normally this heat is radiated within a short distance, but when the flow reverses, the warmed water reaches the intake before the process of radiation can take place. These situations are not frequent, however, and they usually occur during a storm period when the flow is greater than normal and considerable dilution results.

Trash Removal

Trash removal is an ever-present problem in the electric utility industry. The idea that streams are made to carry away everything that man does not want results in an accumulation on the rack bars and screens of every conceivable type of trash from sticks and leaves even, on rare occasions, to human bodies. Hand raking is a costly operation but is necessary to keep the racks clean unless mechanical rakes are used. Revolving screens with high-pressure, water-jet cleaning remove the finer trash. At certain seasons the quantity of this material is large, but normally the disposal problem is not too serious. Water works operators obtaining their water from natural streams may have similar trash removal problems.

Pumps and Piping

Circulating water pumps are of the low-head type. Standard centrifugal pumps have been used for this service in many of the stations. The modern trend, however, is to the vertical-shaft, submerged pumps of mixed-flow design. These pumps have better head-flow characteristics and are nonoverloading. They have the further advantage of a low shutoff head which the true axial-flow type of pump does not. These pumps present a bearing lubrication problem, however. A clean source of water must be available for lubrication at all times, even when the unit is idle, in order to prevent the accumulation of silt or other foreign matter in the bearing. Such an accumulation would damage the bearing on starting. The clean water is usu-

ally obtained by installing a filter system on the unit. All units are motor driven and there are always two identical units, so that if pump or motor trouble occurs, at least one pump can be operated and the generator can carry part load while repairs are being made. If water temperatures are low, one pump is often capable of supplying sufficient water for condensing. The largest pumps on the system have capacities of 75,000 gpm.

Connecting intake and discharge piping is designed for maximum average velocities of 6.7 fps and varies in diameter from 36 in. for some of the smaller units on the system to 48 in. for the 150,000-kw. units.

Condensers

Another ever-present problem of the station operator is that of keeping condensers clean. Water flows through the condenser in small brass tubes, $\frac{3}{4}$–1 in. in diameter around which the steam is condensed. Even when trash racks and traveling screens are used at the intake, sometimes enough foreign matter gets through to seal off many of the openings in the tube sheet. In some condensers, the direction of flow can be reversed by valves in the lines, thus flushing back the debris into the discharge. In other condensers, the only remedy is to shut down and clean the tube sheets by hand through manholes in the condenser cover.

Algae formations inside the tubes tend to clog the water passages and a dirty condenser is not effective. There may be an appreciable rising of the back as the conditions become worse. Growth of the algae is controlled by a maximum of approximately 0.03 lb. of chlorine per 1,000 gal. of circulating condenser water. From time to time, however, it is necessary to clean out the inside of these tubes by shooting rubber plugs through them with compressed air or by pushing wire brushes through the tubes to clean out the algae formation. Acid cleaning is also very effective and economical.

In passing through the condenser, the circulating water picks up heat in the condensing process and returns to the stream or lake a few degrees warmer than it was when it entered the intake. The natural processes of evaporation and radiation in time dissipate this heat to the atmosphere. The cooler the day, the more rapid is the dissipation of heat. Within the condenser a cooler water produces a more efficient condenser cycle. On hot summer days the stream naturally absorbs heat from the sun and air. Consequently, condensers must be designed for the maximum volume of water required at the maximum summer inlet water temperature. If the flow in the stream at that time is less than the volume required for condensing purposes, some recirculation of the water may result and the effect is an increase in the circulating-water temperature and a reduction of efficiency as well as generating capacity. Thus any stream definitely limits the size of generating station that can be installed. This limitation is a function of the minimum volume of water and maximum summer water temperature.

Boiler Feedwater

Water required for boiler feed or makeup must have certain very definite qualities. Not all waters are satisfactory for boiler-feedwater. The water may have the same source as the condenser supply, as at the Waukegan and State Line generating stations on Lake Michigan, or it may come from a public water supply system, as at the Edison Co. stations within Chicago. If the station is remote from a

municipal supply and the stream is not satisfactory for boiler feedwater, a well may be the solution to the problem. Regardless of the source, however, the boiler feedwater must be treated by some softening or demineralizing process or by evaporation and condensing to reduce its mineral content before it goes into the boiler.

The subject of boiler feedwater treatment is a major one and the processes are as varied as the waters used. It is sufficient here to say that boiler feedwater treatment is a problem in the power industry and particularly so in present-day, high-pressure stations.

The source of supply also presents problems. If the water main bringing a supply into the station should be broken at any point, the interruption in the flow could cause a shutdown of the boilers. It is necessary, therefore, to store at least limited quantities of raw as well as treated water for such emergencies. Water storage tanks are as much a problem to the electric utility industry as to the water works industry.

When well water at the station is the source of supply, it is usually necessary to maintain two wells in order to insure an uninterrupted supply, even when the well pumps are being overhauled. The problem of reserve wells to meet demands is not new to water works operators.

Keeping a constant supply of water flowing into high-pressure boilers is a major pumping problem. The cycle is a closed one and there is little loss of water. An addition of approximately 1.5–3 per cent of the total volume of water is required to keep the system full. The addition is automatically controlled through float and automatic valve arrangements. Warm water at the base of the condenser, where a vacuum with a pressure of 29 in. of mercury exists, must be returned to the boiler where temperatures of 1,050 F and pressures of 1,800 psi are present. The discharge pressures on boiler feed pumps may be as high as 2,150 psi on a nominal 1,800 psi system. This pressure is equivalent to almost 5,000 ft head.

The water is first pumped from the condenser through several closed feedwater heaters to an elevated deaerating heater. It then goes to the suction end of the boiler feed pump, a barrel pump having eight to ten stages. There are usually two high-pressure heaters between the pump and the boiler, so that when the water enters the boiler it is at a temperature of approximately 450 F.

The shells of the boiler feed pumps are made of special steel forgings. The internal shafts, diffusers, and impellers are made of 13 per cent chrome steel. Usually all internal pressure fits are made of stainless steels. Pumps normally have balancing drums to overcome the differential thrusts between suction and discharge conditions. Boiler feed pumps are usually driven by high-voltage motors having up to 3,000 hp and 3,600 rpm. Frequently a hydraulic coupling is interposed between the motor and pump as an economy measure in reducing pump discharge head to the minimum required.

Sanitary Water Supply

The water works operator produces a supply of clean water bacteriologically safe for drinking and so necessary in the modern world for sanitary purposes. Homes and industries alike depend on these public water supplies. The electric industry uses substantial quantities of water in the shower and toilet rooms that are provided for the comfort and convenience of the employees. These facilities must be models of cleanliness.

ally obtained by installing a filter system on the unit. All units are motor driven and there are always two identical units, so that if pump or motor trouble occurs, at least one pump can be operated and the generator can carry part load while repairs are being made. If water temperatures are low, one pump is often capable of supplying sufficient water for condensing. The largest pumps on the system have capacities of 75,000 gpm.

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Algae formations inside the tubes tend to clog the water passages and a dirty condenser is not effective. There may be an appreciable falling off in load as the conditions become worse. Growth of the algae is controlled by a maximum of approximately 80 lb of chlorine per mil gal (or 10 ppm) of condenser water. From time to time, however, it is necessary to clean out the inside of these tubes by shooting rubber plugs through them with compressed air or by pushing wire brushes through the tubes to clean out the algae formation. Acid cleaning is also very effective and economical.

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Keeping a constant supply of water flowing into high-pressure boilers is a major pumping problem. The cycle is a closed one and there is little loss of water. An addition of approximately 1.5–3 per cent of the total volume of water is required to keep the system full. The addition is automatically controlled through float and automatic valve arrangements. Warm water at the base of the condenser, where a vacuum with a pressure of 29 in. of mercury exists, must be returned to the boiler where temperatures of 1,050 F and pressures of 1,800 psi are present. The discharge pressures on boiler feed pumps may be as high as 2,150 psi on a nominal 1,800 psi system. This pressure is equivalent to almost 5,000 ft head.

The water is first pumped from the condenser through several closed feedwater heaters to an elevated deaerating heater. It then goes to the suction end of the boiler feed pump, a barrel pump having eight to ten stages. There are usually two high-pressure heaters between the pump and the boiler, so that when the water enters the boiler it is at a temperature of approximately 450 F.

The shells of the boiler feed pumps are made of special steel forgings. The internal shafts, diffusers, and impellers are made of 13 per cent chrome steel. Usually all internal pressure fits are made of stainless steels. Pumps normally have balancing drums to overcome the differential thrusts between suction and discharge conditions. Boiler feed pumps are usually driven by high-voltage motors having up to 3,000 hp and 3,600 rpm. Frequently a hydraulic coupling is interposed between the motor and pump as an economy measure in reducing pump discharge head to the minimum required.

Sanitary Water Supply

The water works operator produces a supply of clean water bacteriologically safe for drinking and so necessary in the modern world for sanitary purposes. Homes and industries alike depend on these public water supplies. The electric industry uses substantial quantities of water in the shower and toilet rooms that are provided for the comfort and convenience of the employees. These facilities must be models of cleanliness.

Water, both hot and cold, in substantial quantities, is essential. If a public water supply is readily available, it is used; if not, wells must be drilled. If wells supply the boiler feed requirements, the sanitary water is usually taken from the same source. If sanitary sewers are within a reasonable distance, they are used, and, if not, it is necessary to provide modern sewage treatment plants. The electric generating station operator, therefore, may have to become a water and sewage works expert.

Incidental Water Problems

The trash problem at intakes for circulating water is a constant source of irritation in the electric utility industry, but it becomes a major nuisance in periods of flood. Enormous quantities of floating debris reach the racks and screens, requiring constant labor for raking racks, cleaning screens, and keeping pumps operating. A clogged screen may so reduce the flow into the pump pit that there is not sufficient volume to keep the pumps operating. The loss of condensing water means loss of vacuum and an interruption in the power supply. Eternal vigilance and hard work is the price that must be paid to keep the generator on the line at such times.

The large quantities of silt and mud carried by floodwaters are deposited at the base of the rack bars, in the pump pits, and in the condensers. A major housecleaning is necessary periodically to remove this material.

Ice can be a very troublesome element in severe winter weather. Certain atmospheric conditions may produce ice particles which are suspended in the flowing water. This anchor ice, as it is sometimes called, can congeal on cold rack bars and almost completely seal off the intake in a very short time. Heavy floating ice can be just as great a source of trouble. Water is at or very near 32 F at these times and the extreme difference in temperature between the inside and outside of condenser tubes also causes some operating problems. A small quantity of warmed condenser water recirculated into the intake usually helps to solve the problems by keeping rack bars above a freezing temperature, melting the floating ice, and raising the intake water temperature to values which produce fewer condenser operating troubles.

Not all of the Edison stations obtain their fuel through water transportation, but those that do must maintain docks along the Illinois Waterway. More than 5,000,000 tons of coal are waterborne annually on the Illinois Waterway to the Chicago stations. The problems incidental to the maintenance of this equipment are many and varied.

Conclusions

The electric utility industry is a substantial user of water for many purposes in its generating stations. Its condensers are thirsty mammoths through which flow many million gallons of water per day. Although power is produced in Commonwealth Edison system stations more efficiently by using a large volume of water, the author hopes no one will think that kilowatt hours are diluted with Chicago River water. The electric utility industry meets its water problems and keeps the system running. No doubt the water works plant is faced with many water problems. If electric power is used for pumping, the water works operator should remember that the operator at the other end of the electric line supplying power continuously may also be having plenty of water problems.

Long-Range Water Supply Planning for Wichita

By Robert H. Hess

A paper presented on May 8, 1952, at the Annual Conference, Kansas City, Mo., by Robert H. Hess, Supt., Municipal Water Supply, Wichita, Kan.

THE water system in Wichita is unique in that the production and purification facilities are owned and operated by the city of Wichita and the pumping station and distribution system are owned by the Wichita Water Co., a subsidiary of the American Water Works Co., Inc. The background for this unusual arrangement will be described briefly.

Before 1940 the water supply for Wichita was obtained from shallow wells which tapped the underflow of the Arkansas River. Although these wells, which were the property of the Wichita Water Co., provided an adequate quantity of water at that time, the supply was very unsatisfactory because of its high hardness and high chloride content. The water from this source had a total hardness of 450 ppm and contained 400–700 ppm of chlorides.

In the interval from 1924 to 1937 several investigations were made in an attempt to locate a new source of supply which would provide Wichita with water of better quality. In 1938 the investigation which led to the development of the present municipal well field was initiated by the city of Wichita in cooperation with the state and federal geological surveys and the Kansas Board of Health. Wichita decided to finance, construct, and operate a new source of supply from wells in the Equus Beds of Harvey County (Fig. 1). The Wichita Water Co. had investigated this source in 1924 but the idea was abandoned because the increase in water rates required to finance the project was considered too great.

The construction program was completed in 1940 and the ctiy of Wichita entered into a contract to sell water at wholesale to the Wichita Water Co. Under this agreement, the city is responsible for supplying an adequate quantity of good water to the clearwater reservoir owned by the Wichita Water Co., which, in turn, is responsible for the delivery of the finished water to the ultimate consumer. Thus, Wichita water is municipally produced and is distributed by private enterprise.

Industrial Development

Early in its development, the city established itself as a cattle and milling center. These industries constitute an important part of the present commercial activity. The discovery of oil shortly after 1900 added impetus to the city's growth. From 1930 to 1940, the city, in common with other areas passing through the depression period, experienced only slight gains. The census showed a population of 114,966 within the city limits in 1940 before

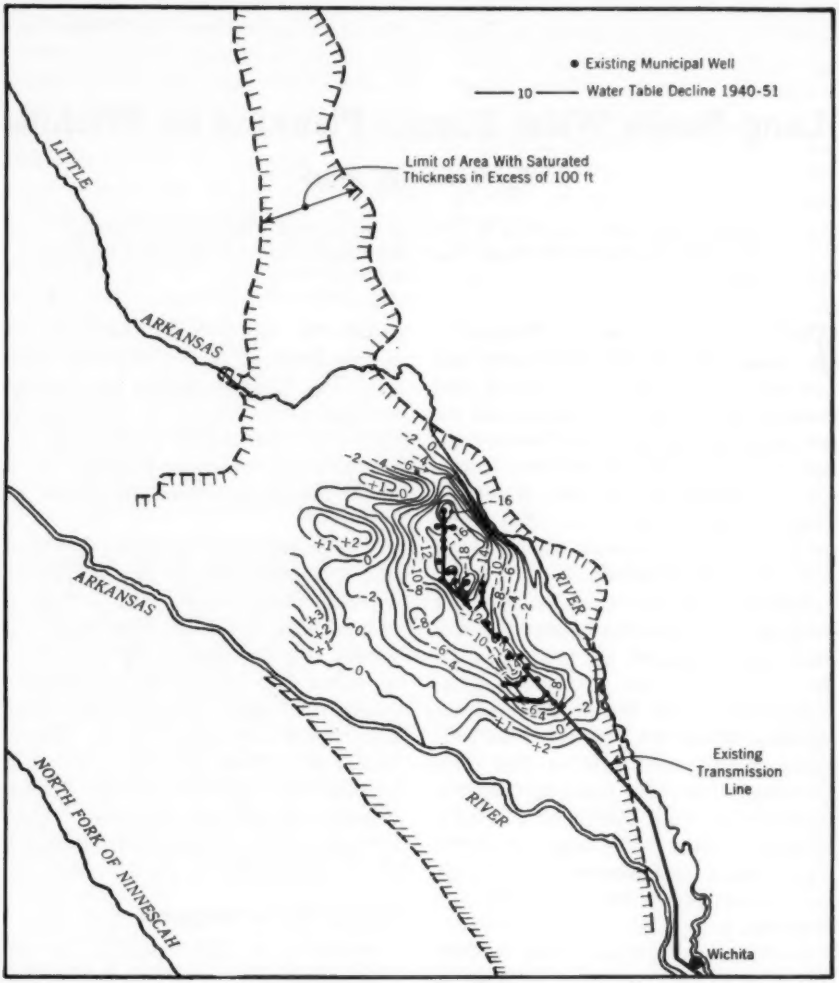

Fig. 1. Wichita Well Field

The well field is located in an area having a saturated thickness in excess of 100 ft.

the beginning of industrial activity necessitated by World War II.

From 1941 to 1946 the development of Wichita was dominated by the aircraft industry. In 1943 the combined employment of aircraft companies reached a peak of approximately 41,500 workers. In 1945 this employment fell to approximately 37,700, and in 1948 it dropped to a minimum of 4,650.

From 1947 through 1949 Wichita experienced a very successful transition from defense production to diver-

sified production of consumer goods. At the end of this period the major portion of the skilled defense workers had been absorbed by the expansion of established and new industries.

Additional momentum was imparted to the industrial growth of Wichita in 1950 by the expansion of military needs, and by November 1951 the total employment by the aircraft industries reached 38,250. In March 1952 em-

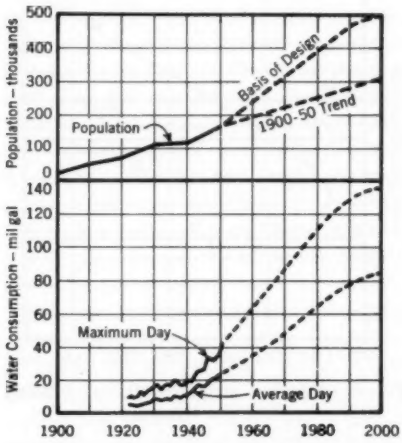

Fig. 2. Population and Water Consumption Trends

Present trends indicate that Wichita should anticipate serving a population of 425,000 by 1985 and 500,000 by 2000.

ployment by aircraft industries was 39,600, and total employment in the metropolitan area was approximately 112,600.

The industrial activity of Wichita is at an extremely high level and it appears that the industrial growth will continue at a high rate during the decade 1951–60. Regardless of the long-range stability of the aircraft industry, it appears that the impetus created by the expansion of this industry will be sufficient to insure a substantial increase in the permanent industrial capacity of Wichita.

Future Demands

The population of Wichita, as determined by the 1950 census, was 166,036. If the population grows at the average rate experienced from 1900–50, the population in the year 2000 will be 310,000 (Fig. 2). The present rate of growth is much higher than the average rate experienced in the past, however, and it appears that this trend will continue into the future. Projected curves which reflect the present increased rate of growth indicate that the city should anticipate serving a population of 425,000 by the year 1985 and 500,000 by the year 2000.

From the study of the population and industrial trends in Wichita, it is felt that all improvements should be planned to serve a population of 425,000 and phased for construction to supply the needs of the city until approximately 1985. The water supply, as finally developed, should be capable of serving a population of at least 500,000. Considerable time will be required for planning, financing, and construction, and it is probable that the first stage of a major program could not be completed until 1955. It is thought that this long-range program should be designed to serve the needs of the city for at least 30 years after the facilities are placed in service.

The average per capita water consumption of Wichita, as of other municipalities, has increased at a rapid rate during the past 30 years. This increase is due principally to higher standards of living and improved facilities for sanitation. As a result of the increased use of home air conditioning, home garbage disposal units, dishwashing machines, automatic laundry

machines, and extra bathrooms, the future per capita consumption of water can be expected to increase above the present level.

Wichita's location in a region of relatively dry climate presents a problem in maximum daily demand. The ratio of maximum to average daily demand has varied from 145 to 222 per cent. As cities increase in size, the ratio between maximum and average daily demand usually decreases because the industrial consumption is not affected by temperature and rainfall to the same extent as domestic and commercial consumption. It is estimated that the average water consumption in Wichita will reach 170 gpcd in 1985. Thus, in order to supply a population of 425,000, it would be necessary to provide capacity to supply average demands of 73 mgd and maximum demands of 165 per cent of the average or 120 mgd.

Present Supply

The present water supply for Wichita is obtained from 35 wells in the Equus Beds of Harvey County (Fig. 1). Water from these wells is of a very satisfactory quality but does require treatment for the removal of iron, manganese, and some carbonate hardness.

Extensive studies of the probable yield of the existing well field have been made by representatives of the U.S. Geological Survey and the Kansas Geological Survey. These authorities concur in the opinion that the present wells have a potential perennial average yield of 30 mgd. The wells average 200 ft in depth and the average capacity is approximately 1.6 mgd per well. A system of collecting mains gathers the water from the individual wells and delivers it through 17.5 miles of 48-in. cast-iron pipe to the city's purification plant. The capacity of this 48-in. pipeline under present operating conditions is 37.5 mgd. (Fig. 3). This capacity can be increased to 48 mgd by the construction of a booster pumping station.

The water treatment plant, constructed in 1940 and expanded in 1947,

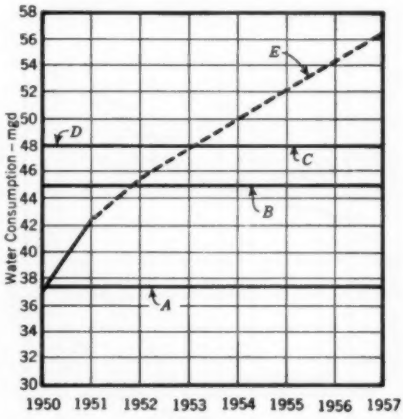

Fig. 3. Demand and Capacity of Present Wichita System

The italic letters refer to the following: A—*existing transmission line, capacity 37.5 mgd;* B—*existing treatment plant, capacity, 45 mgd;* C—*existing 35 wells in Equus beds, capacity 48 mgd;* D—*existing transmission line with new booster station, capacity 48 mgd; and* E—*estimated maximum daily demand. The maximum day in 1952 was June 30 when the demand was 523 mil gal.*

has a normal capacity of 48 mgd. Filtered-water storage is provided by a 1-mil gal clear well and two 3-mil gal filtered-water reservoirs, which are a part of the city plant, and a 3.8-mil gal filtered-water reservoir owned by the Wichita Water Co.

In 1947, the city constructed seven emergency wells in the vicinity of the

purification plant. The original purpose of these wells was to augment the capacity of the old wells of the Wichita Water Co., which are kept in operating condition, to provide an emergency supply as protection against a break in the single transmission line from the well field. It has been necessary to utilize this emergency supply to meet demands which were in excess of the transmission capacity from the main well field.

The water from the emergency wells comes from the underflow of the Arkansas River and is the same as that used for the city water supply before 1940. As previously stated, the water is of unsatisfactory quality because of its high hardness and high chloride content but can be blended with the water from the Equus Beds without noticeable adverse effects on the quality of the finished water.

Several potential sources of water supply have been studied to determine if they would provide an adequate quantity of water of acceptable quality and if the cost of development would be economically feasible. The potential sources which do meet the basic requirements include: [1] expansion of the existing well field; [2] supply from the north fork of the Ninnescah River; and [3] partial well field expansion and supply from Kanopolis Reservoir.

Well Field Expansion

Comprehensive studies made over the past decade have determined that the recharge to the Equus Beds area during normal years is approximately 20 per cent of the total rainfall. Based on an average rainfall of 30 in. per year, this recharge results in a total recharge of 6 in. or 320 acre-ft per square mile. It is estimated that the existing wells influence an area of approximately 85 sq miles. The recharge available to these wells is therefore approximately 27,000 acre-ft per year.

The Equus Beds extend over an area approximately 50 miles long and 20 miles wide. It is estimated that the area of influence of the well field could be expanded to reach practically all of the area having a saturated thickness in excess of 100 ft (Fig. 1). This expansion would increase the area of influence to approximately 310 sq miles, indicating a normal recharge of approximately 100,000 acre-ft per year or an average of 90 mgd.

It is not considered practical to develop all of the 310 sq miles because of the concentration of chlorides in certain portions of the area. By carefully spacing the wells to minimize the danger of salt water intrusion, however, it is estimated that the well field can be expanded to provide a normal average supply of 73 mgd.

The observations of water levels in the existing well field cover a period of several years. During this period rainfall has been above normal and it is not possible to predict with certainty the effects of a series of extremely dry years. The quantity of water in the ground water reservoir is extremely large and would sustain a pumpage of 73 mgd for a period of 5 or 6 years even without recharge. Continued withdrawals under these conditions, however, would result in a lowering of the ground water table which would be accompanied by a reduction in the normal pumping rate of each well. Under conditions of average rainfall, it is estimated that the normal lowering of the ground water table would be approximately 20 ft and that the average drawdown at each well would be approximately 40 ft. During periods of

prolonged drought, the lowering of the ground water table might be as much as 32 ft.

During the past 10 years, the city has deepened approximately 140 farm wells. The expansion of the existing well field to influence an area of 310 sq miles would increase substantially the number of farm wells that would require deepening. It has been necessary, in the past, for the city of Wichita to pay damages based on loss of value of a few farms in the area as a result of a general lowering of the water table resulting in the drying up of several spring-fed streams.

Although the exact extent to which the well field can ultimately be developed is unknown at present, this plan has one outstanding advantage. The well field can be extended to provide a substantial increase in water supply and at the same time allow deferment of a large portion of the ultimate development until the future growth of Wichita and the ultimate dependable yield of the Equus Beds can be predicted with greater accuracy.

The program, which would provide an average of 73 mgd and a peak of 120 mgd, would require 60 additional wells and could be designed in three stages, at a total cost of $22,986,685, as follows:

Stage 1. To be constructed in 1953, and to consist of 20 new wells, 118,800 ft of 66-in. transmission main to the filter plant, 14,800 ft of 42-in. connecting pipeline, well collecting lines, and improvements to water treatment plant to provide 32 mgd additional capacity —cost $11,525,172.

Stage 2. To be constructed in 1964, and to consist of 20 new wells, 77,700 ft of 60- and 54-in. transmission main, well collecting lines, and improvements to water treatment plant to provide 48 mgd additional capacity—cost $8,250,-216.

Stage 3. To be constructed in 1975, and to consist of 20 new wells and well collecting lines—cost $3,201,297.

Supplemental River Supply

For the past several years, the U.S. Bureau of Reclamation has been making a general inventory of water needs and potential developments in the Arkansas River Basin. As a result of these investigations, the bureau has concluded that a reservoir located on the north fork of the Ninnescah River will provide an adequate and dependable source of supplemental water supply for the city of Wichita. In general, the author's study has verified the bureau's findings.

The dam site north of Cheney will impound the runoff from a tributary area containing approximately 860 sq miles. On the basis of studies of estimated runoff from this tributary area and estimates of probable monthly evaporation from the lake surface, it has been determined that the reservoir should provide an effective storage capacity of 152,000 acre-ft in order to supply an average demand of 43 mgd during a period of drought such as that experienced from 1930 to 1940. This supply is the amount that would be required to supplement the existing well supply in order to provide an average of 73 mgd for a population of 425,000.

The Ninnescah River, compared with other streams in the area, carries a very small quantity of silt, but there is considerable uncertainty on the quantities of sand that might be deposited in the reservoirs during periods of flood. A dam approximately 17,000

ft long would be required and the area of the lake at spillway elevation would be approximately 9,300 acres with a maximum working depth of approximately 30 ft.

The chemical quality of water from the north fork of the Ninnescah River is not as good as that from the Equus Beds but is, in general, better than water from Kanopolis. Inasmuch as a large portion of the surface area would have a depth of less than 10 ft, the control of odors and tastes might involve substantial treatment problems.

The development of the Ninnescah supply does not lend itself to stage construction as does the plan for the expansion of the well field in the Equus Beds. A large portion of such a project must be completed before any water could be made available from this source. The project could be divided, however, into two stages, at a total cost of $32,800,498, as follows:

Stage 1. To be constructed in 1953, and to consist of dam, raw-water pumping station, 132,100 ft of 72- and 60-in. transmission main, and improvements to water treatment plant to provide 32 mgd additional capacity—cost $28,350,723.

Stage 2. To be constructed in 1964, and to consist of expansion of raw-water pumping station and improvements to water treatment plant to provide 48 mgd additional capacity—cost $4,449,775.

Partial Well Field Expansion and Reservoir Supply

The development of a supplementary supply from Kanopolis Reservoir is very attractive from the standpoint of allowing deferment of a substantial portion of the ultimate project. Studies of alternate pipeline locations between Wichita and Kanopolis show that the best and most economical route will pass through that portion of the well field which is most attractive for future development. Hence, it would be possible for the city to proceed with Stage 1 of the plan proposed for the expansion of the well field and then, at a later date, either proceed with further expansions of the well field or extend the transmission pipeline to Kanopolis Reservoir.

Kanopolis Reservoir, located on the Smoky Hill River approximately 72 miles north of Wichita, was constructed as a flood control project. The reservoir provides a total storage capacity of 450,000 acre-ft of which 400,000 is allocated for flood control and 50,000 is for siltation and maintenance of the sanitary condition of the Smoky Hill River downstream.

Cedar Bluff Reservoir, located on the Smoky Hill River approximately 90 miles upstream from Kanopolis, was recently completed by the U.S. Bureau of Reclamation primarily for irrigation purposes. This reservoir has a total capacity of approximately 360,000 acre-ft. As the Kanopolis and Cedar Bluff reservoirs are on the same drainage area, they must be considered as a unit and the amount of storage which might be made available for water supply purposes would depend on the operation of the two reservoirs. The most feasible plan for securing a supplemental supply from Kanopolis Reservoir would probably require the allocation of a substantial portion of the irrigation storage in Cedar Bluff Reservoir which could be released to Kanopolis Reservoir as needed. Such a plan would require an agreement with the U.S. Bureau of Reclamation and the U.S. Corps of Engineers cov-

ering the purchase of water and the construction of diversion works which would deliver water to a pumping station to be constructed and operated by the city of Wichita.

The chemical quality of water from Kanopolis Reservoir is slightly less desirable than that of water from the north fork of the Ninnescah River as it is somewhat higher in noncarbonate hardness. During periods of extreme drought, the chloride concentration might reach 373 ppm but the water could be blended with water from the Equus Beds for a maximum of 190 ppm of chlorides.

The development of a supplemental supply from additional wells and from Kanopolis Reservoir would provide a greater ultimate supply than either of the other plans presented. This program could be divided into two stages, at a total cost of $32,923,374, as follows:

Stage 1. To be constructed in 1953 and to consist of 20 new wells, 133,600 ft of 66- and 42-in. transmission main, well collecting lines, and improvements to water treatment plant to provide 32 mgd additional capacity—cost $11,479,996.

Stage 2. To be constructed in 1964 and to consist of intake and pumping station at Kanopolis, 265,000 ft of 66-in. transmission main, and improvements to filtration plant to provide 48 mgd additional capacity—cost $21,443,378.

Comparison of Plans

Each of the long-range water supply plans presented would provide a substantial increase in water supply for Wichita and would, in general, meet the basic requirements. Each of the plans would require a large capital expenditure, however, and each has certain undesirable features. In the final analysis, the plan selected must be the one that will impose the smallest financial burden on the city and, at the same time, provide positive assurance of an adequate water supply for the future.

The full development of the well field would result in the lowest total cost and is the plan best suited for stage development as the water supply needs of the city increase. The expansion of this source to supply average demands in excess of 50 mgd, however, should be considered as a marginal investment until observations during a period of extended drought indicate the ultimate dependable yield.

A supplementary supply from a reservoir constructed on the north fork of the Ninnescah River, which would be utilized in connection with the existing supply, would provide adequate water supply to serve a future population of 425,000. Such a development would require a very large initial investment as the supply portion of this project is not subject to stage development. In the event the population of Wichita grows at a much slower rate than is now indicated, or should the population become stabilized at 300,000 or less as a result of a major economic change, the amortization of the investment required to develop this project would impose a sizable burden upon the citizens of Wichita.

A partial expansion of the existing well field to be supplemented at a later date by the expansion of a water transmission main to Kanopolis Reservoir would provide for the greatest quantity of total water supply. This program would provide a very flexible plan which is ideally suited to stage development and would allow deferment

of the major portion of the total cost until such time as the growth of Wichita made necessary the ultimate development.

Conclusion

At the present rate of growth, it is essential that Wichita develop an additional source of water by 1955. In order to meet the need until 1955, it will be necessary to provide additional facilities by constructing a booster pumping station on the existing 48-in. transmission line and installing a second filter effluent line between the plant and the clear-water reservoirs.

It is anticipated that a proposal authorizing Stage 1 of the third plan described—partial well field expansion and supply from Kanopolis Reservoir —in the amount of $11,479,996, will be submitted to the citizens of Wichita Nov. 4, 1952.

Wichita must continue negotiations with the U.S. Corps of Engineers, the Bureau of Reclamation, and such other federal agencies as are involved, in order to work out a plan which will make available to the city a firm and positive source of supplemental water supply from Kanopolis Reservoir.

Acknowledgment

The development of a long-range water supply plan for Wichita has been completed by Black & Veatch, Consulting Engrs., Kansas City, Mo., and was submitted to the Wichita Board of City Commissioners in the form of a report on Apr. 21, 1952. The author has drawn liberally from this report and wishes to express deep appreciation to N. T. Veatch, Ray E. Lawrence, and E. E. Bolls of that firm for their many helpful suggestions and technical advice.

Domestic and European Molecular Filter Membranes

By Harold F. Clark, Harold L. Jeter, Edwin E. Geldreich, and Paul W. Kabler

A paper presented on Mar. 26, 1952, at the Illinois Section Meeting, Chicago, by Harold F. Clark, Bacteriologist, Harold L. Jeter, Bacteriologist, Edwin E. Geldreich, Bacteriologist, and Paul W. Kahler, Chief, Bacteriology Section, all of the Environmental Health Center, U.S. Public Health Service, Cincinnati, Ohio.

FILTER techniques for the bacteriological analysis of water and fluids have been used in Europe for a number of years. Recently (1) the U.S. Public Health Service Environmental Health Center at Cincinnati suggested improved rapid filtration procedures for use in bacterial counts, coliform estimations, and isolation of some of the pathogens of the *Salmonella* group from waters. Those tentative procedures required 10 hours for bacterial counts, 15 hours for coliforms, and 30 hours for *Salmonella typhosa*.

The filter membranes used in the United States are disks 48 mm in diameter. Pores in the membrane are tubular and roughly parallel to the direction of flow of a liquid during filtration. The membrane has an effective diameter of approximately 35 mm and an effective area of 9.62 sq cm. The effective pore diameter of membranes used in bacteriological work is approximately 0.7 μ.

Hydrosol membranes used to date in most investigations in the United States are of domestic manufacture. Alexander Goetz (2), after a detailed investigation of the European membrane, cooperated in the development of the hydrosol membrane made from domestic materials. Both domestic and European membranes can be purchased in the United States. The authors investigated and describe in this paper the technical procedures for each type. Colony data are compared on a series of duplicate water samples.

Membrane Sterilization

Pressure sterilization at elevated temperatures injured both types of membranes.* The domestic membrane was sterilized by exposure to ethylene oxide but may, in an emergency, be used after boiling gently in distilled water for 20 min.

Directions supplied with the European membrane recommended gentle boiling in distilled water for 20 min and repeating the procedure a second time with fresh distilled water. According to the manufacturer, the boiling periods for the European membranes serve the double purpose of extracting any residual toxic substances and of sterilizing. The European membranes used in this investi-

* Subsequent work has shown that American membranes can be safely sterilized at 10 lb pressure for 10 min.

gation were boiled gently for two successive 20-min periods and one additional 5-min period.

Sample Filtration

The domestic membrane will filter approximately 700 ml of distilled water per min at room temperature with a differential pressure of 700 mm of mercury. As the differential pressure is reduced, the rate of filtration is slowed. At 50 mm the rate is 70 ml per min. There is no difference in the efficiency of domestic filters, either in removal of bacteria, or in subsequent growth, at any usable differential pressure.

The European type of membrane is injured by using excessive differential pressure during the filtration procedure. A manufacturer of European membranes recommends a differential pressure of not more than 60 mm of mercury for filtration. In their laboratory the authors have found that a differential pressure of 360 mm may be safely used with a filtration rate of approximately 70 ml per min. Excessive filtration pressures on European membranes do not result in the passage of organisms through the filter but there is a serious reduction in the number of colonies on subsequent cultivation.

Media

The authors found that the same media were satisfactory for both types of membranes. All media were used in the broth form. Concentrations of most nutrient substances were increased at least two times more than the formulas described for usual laboratory media. Some substances, especially dyes, are selectively adsorbed by the membrane. The adsorptive capacity of a membrane can be satisfied by its saturation with certain dyes before the filtration procedure (3)—for example, the authors have found it feasible to use a mixture of eosin and methylene blue as an indicator in broth medium only after the membrane has been saturated with methylene blue and washed free of the excess dye before filtration.

For bacterial counts on water by the colony count method, the medium was lactose Albimi broth made as follows:

Albimi peptone M	40 g
Yeast autolysate (Albimi)	6 g
Dipotassium hydrogen phosphate	3 g
Sodium chloride	5 g
Lactose	5 g
Distilled water	1,000 ml

Pipet in 30-ml quantities and sterilize at 121 C for 15 min.

This medium was both a general purpose medium and one of the essential media in the coliform examination.

The Endo broth (Environmental Health Center modification) was not difficult to prepare but required careful standardization of the fuchsin-sulfite mixture. The three components of the Endo broth are stable but, after mixing, must be used in 12 hours. The stable components include:

1. *Basal medium*

Lactose	20 g
Neopeptone *	20 g
Dipotassium hydrogen phosphate	7 g
Distilled water	1,000 ml

Dissolve ingredients in water, adjust to pH 7.5 with potassium hydroxide solution, pipet in 30-ml quantities, and sterilize at 121 C for 15 min.

2. *Sodium sulfite solution, 9 per cent*

Weigh 0.9 g of sodium sulfite on sterile paper and place in 50-ml sterile tubes. Dis-

* A product of Difco Laboratories, Inc., Detroit, was used.

solve in 10 ml of sterile phosphate water and use within 12 hours.

3. *Fuchsin solution, 3 per cent*

Basic fuchsin (certified dye)	3 g
Alcohol	50 ml
Distilled water, to make	100 ml

Place alcohol in a 100-ml volumetric flask, dissolve fuchsin in alcohol, and add water to the 100-ml mark. This solution is stable if protected against evaporation.

In the standardization of the Endo broth, a series of eight 30-ml tubes of basal broth was placed in a rack. A fresh solution of 9 per cent sodium sulfite was prepared by adding 10 ml of sterile phosphate buffer water to the dry powder. Then 1 ml of this sulfite solution was added to each broth tube. The fuchsin sulfite broth mixture was prepared by adding 0.6 ml of dye solution to the first tube and the quantity was increased by 0.2 ml in each successive tube. Sixteen replicate portions of a water containing between 10 and 50 coliform organisms were filtered through membranes and two of the membranes were placed on each concentration of fuchsin-sulfite broth. The quantity of the broth that had the maximum number of coliform colonies with a marked metallic surface sheen represented the ideal fuchsin-sulfite ratio for Endo broth. The dye solution was found to be stable. Only one titration was necessary for each new dye solution. One liter of dye solution was sufficient for approximately 10,000 coliform examinations.

Incubation

Both types of membranes were incubated in an atmosphere of saturated humidity at 35 C. There was no significant difference in the quantitative recovery rates at incubation temperatures ranging from 34 to 39 C.

Counting Colonies

Membranes of both types were counted at a magnification of 15 diameters. For a total colony count, the angle of illumination with the surface of the membrane was approximately 20 deg. For counting and classification of coliforms, a 60–80-deg angle of illumination was used.

Domestic membranes had a grid printed on the surface. Each square of the grid was equal to one hundredth of the effective filter area. As the European membrane had no grid, a transparent overlay was used when counting colonies on dense membranes.

TABLE 1

Comparison of Coliform Colonies on European and Domestic Membranes

Source of Sample	Sample Quantity Examined *ml*	No. Coliform Colonies	
		Domestic Membrane	European Membrane
Sewage	0.0001	68	45
Ohio River	0.01	33	22
Farm well	1	46	49
Farm well	1	8	13
Creek	1	73	74
Farm well	2	34	31
Farm well	3	36	39
Settled river water	3	44	42
Settled river water	3	52	52
Settled river water	5	38	44
Lake	5	5	3
Well	7	220	240
Well	7	89	78
Lake	10	9	12
Lake	10	40	40
Lake	10	30	27
Lake	15	60	58
Lake	15	15	13
Lake	20	65	64
Lake	20	39	39
Total colonies		1,004	985
Avg. per membrane		50	49

All the colonies on the entire membrane were counted.

In a coliform estimation, only those colonies with a dark red color plus a metallic surface sheen were counted as coliform organisms. Total colony counts were not made from Endo medium because the growth of some non-coliform bacteria was inhibited by the fuchsin-sulfite indicator.

Results

In comparing the two types of membrane at the Environmental Health Center, ten replicate portions were filtered from each sample, using five domestic and five European membranes. The data (Table 1) for each membrane type show the average number of coliform organisms from the five replicate portions. Several sources of samples were used including one sewage, one Ohio River, three settled Ohio River, six rural wells, one woodland creek, and eight lake waters.

TABLE 2

Comparison of Colony Density on Domestic and European Membranes

Source of Sample	Sample Quantity Examined *ml*	No. Coliform Colonies	
		Domestic Membrane	European Membrane
Sewage	0.0003	190	150
Settled river water	3	240	220
Settled river water	3	440	440
Well	3	190	180
Well	5	280	250
Lake	10	30	27
Lake	10	49	50
Lake	20	96	100
Well	20	55	48
Lake	25	52	57
Total colonies		1,622	1,522
Avg. per membrane		162	152

The domestic membrane gave higher results ten times, lower results seven times, and equal results three times on comparison with the European type. The average number of coliform colonies per membrane, on twenty examinations, was 50 on the domestic type and 49 on the European. The slight difference in favor of the domestic type is not of sufficient magnitude to prevent acceptable coliform data being obtained from both types of membranes.

The total colony counts on the membranes were compared. The types of samples were: one sewage, two settled Ohio River, three wells, and four lakes.

TABLE 3

Comparison of Esch. coli *Densities on Domestic and European Membranes*

No. *Esch. coli* Organisms (Plate Count)	No. *Esch. coli* Colonies		Recovery Ratio—*Membrane Plus Plate Count*	
	Domestic Membrane	European Membrane	Domestic Membrane	European Membrane
60	67	62	1.1	1.0
60	62	58	1.0	0.97
66	66	60	1.0	0.91
66	65	66	0.99	1.0
Avg.			1.0	0.97

The average number of colonies (Table 2) was 162 on the domestic membranes and 152 on the European. The domestic membranes were higher six times and lower four times in the total counts. The difference is favorable to the domestic membrane but it is not great enough to prevent acceptance of data from the European type.

The recovery of *Esch. coli* suspended in sterile phosphate water was measured according to the procedure described for coliform organisms in water. The number of *Esch. coli* planted on each

membrane was estimated from five replicate nutrient agar plate counts on a stock suspension, diluting 0.5 ml of the stock suspension with 100 ml of sterile water. The 100-ml dilution was filtered through each membrane and the membrane was washed with another 100 ml of sterile phosphate water before cultivation. The average recovery of *Esch. coli* (Table 3) on Endo broth by the filtration technique compared favorably with the recovery on the nutrient agar plate count.

Summary

The European membrane was sterilized by boiling in distilled water and was used wet. It was sensitive to differential pressures in excess of 360 mm of mercury, had slower filtration rates, and had no grid lines as a counting guide. The domestic membrane was chemically sterilized using ethylene oxide gas. It was stored in dry sterile petri dishes for use without further treatment, was not sensitive to a differential pressure of 700 mm or less of mercury, had a rapid filtration rate, and had grid lines as a counting aid.

The bacteriological data were in reasonably good agreement when each type of membrane was used according to the procedures described. The ease and convenience in the technical procedure and rapid filtration rates were important factors in favor of the domestic membranes.

Comparative procedures for each type of membrane and a biological titration method for Endo broth have been given, and data on each type of membrane have been compared using duplicate water samples from several sources.

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Silica Removal Characteristics of Highly Basic Anion Exchangers

By M. E. Gilwood, Calvin Calmon, and A. H. Greer

A contribution to the Journal by M. E. Gilwood, Director of Research, The Permutit Co., New York; and Calvin Calmon, Chief Research Chemist, and A. H. Greer, Research Chemist, both of The Permutit Co., Birmingham, N.J.

DEMINERALIZED, silica-free water has become increasingly important in supplying the boiler makeup requirements for high-pressure boiler plants operating at pressures of 1,400 psi or higher. In the operation of high-pressure boiler plants, it is essential to have available a source of either demineralized or distilled water of low electrolyte content having a maximum dissolved silica (SiO_2) content of 0.0–0.2 ppm. It has been found that, in order to avoid the development of siliceous deposits on the turbine blades of turbogenerators, it is necessary to maintain an extremely low silica content in the concentrated water in such boilers. Silica levels normally maintained in the concentrated boiler water are in the range of 1–5 ppm. Until the development of demineralizing, evaporators were the only means available to produce a suitable low-silica, low-electrolyte water supply for these high-pressure boiler plants.

Two-Step Demineralization

The present two-step process for demineralizing combined with silica removal by ion exchange was first described in 1947 (1). The process is summarized in Fig. 1. It is essential for satisfactory silica removal that the anion exchanger employed in the last unit be a strongly basic anion-exchange resin regenerated with sodium hydroxide.

The raw water containing the usual constituents—bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), calcium (Ca), magnesium (Mg), sodium (Na), and silica (SiO_2)—is passed through a hydrogen cation-exchange unit. The calcium, magnesium, and sodium are exchanged in the cation exchanger for hydrogen ion, thus forming equivalent amounts of carbonic (H_2CO_3), sulfuric (H_2SO_4), and hydrochloric (HCl) acids. The dissolved silica in the water appears as silicic acid (H_2SiO_3). The reaction which takes place in the hydrogen exchanger may be indicated by the following reaction where Z is the hydrogen exchanger:

$$\left.\begin{matrix}Ca^{++}\\Mg^{++}\\2Na^{+}\end{matrix}\right\}\left\{\begin{matrix}2HCO_3^-\\SO_4^=\\2Cl^-\end{matrix}\right. + H_2Z \rightarrow \left.\begin{matrix}Ca\\Mg\\Na_2\end{matrix}\right\}Z + \begin{matrix}2H_2CO_3\\H_2SO_4\\2HCl\end{matrix}$$

The carbonic acid produced as a result of the hydrogen-exchange reaction breaks down into free carbon dioxide (CO_2) and is removed readily

by means of degasification or aeration. The water is then passed into the highly basic anion exchanger where the sulfuric acid, hydrochloric acid, residual carbonic acid, and the silicic acid are absorbed:

$$H^{+}\begin{cases}HCO_3^{-}\\ \frac{1}{2}SO_4^{=}\\ Cl^{-}\\ HSiO_3^{-}\end{cases} + R_4NOH \rightarrow R_4N\begin{cases}HCO_3^{-}\\ \frac{1}{2}SO_4^{=}\\ Cl^{-}\\ HSiO_3^{-}\end{cases} + H_2O$$

where R_4N is the highly basic anion-exchange resin. The treated effluent is extremely low in electrolyte content and is free of dissolved silica.

Mixed-Bed Demineralizing

A second method of demineralizing water with silica removal became available with the further development of mixed-bed demineralizing. The mixed-bed demineralizer consists of a single ion-exchange unit containing a homogeneous mixture of a hydrogen cation-exchange resin and a highly basic anion-exchange resin. In normal operation, the flow of water is downward through the mixed exchange resin bed. When the capacity of the exchange resins has been exhausted, the unit is backwashed to separate the two resins hydraulically. The lower-density anion-exchange resin goes to the top of the bed. The separated exchangers are then regenerated separately, rinsed, and finally remixed to form a homogeneous mixed bed for the next run. The effectiveness of silica removal and the economy of both of these processes are dependent to a great degree on the characteristics of the highly basic anion exchangers employed.

Anion-Exchange Resins

The first highly basic anion-exchange resin available for this purpose was Ionac A–300 * which contains some quaternary amine groups in its structure. These quaternary amine groups are the active centers which make it possible to absorb silica from water.

During the past three years newer, strongly basic, anion-exchange resins capable of removing silica from water have become available. These new resins employ polystyrene as their foundation matrix, to which the active quaternary amine groups are attached. Two fundamental types of such highly basic, quaternary amine, polystyrene resins have been developed (*2, 3*):

Type I	Type II
Permutit S–1 *	Permutit S–2 *
Dowex 1 †	Nalcite SAR †
Amberlite IRA–400 ‡	Amberlite IRA–410 ‡

A resin of Type I was first introduced for removal of silica from water. The Type I resin was an improvement over the Ionac A–300 type of resin because it has a higher capacity for removing silica from water and requires less regenerant caustic soda per kilograin of anions removed. The Type II resins (*3*), however, have become of greater importance for removal of silica from water during the past two years because they give much higher exchange capacities to a silica endpoint than the Type I resins. Furthermore, they are more

* A product of The Permutit Co., New York.

† Products of Dow Chemical Co., Midland, Mich.

‡ Products of Rohm & Haas Co., Philadelphia.

efficient in their requirements of caustic soda per kilograin of anions removed. For this reason, Type II resins are most commonly used now for silica-removal–demineralizing installations. The Type I resins contain only alkyl quaternary groups, whereas the Type II contain some alkanol groups in the quaternary structure.

The highly basic resins have found their main application in the two-step demineralizing process and in the mixed-bed demineralizing process. Thus far, the more extensive use has been in the two-step type of installation, which appears to be much cheaper to operate than the mixed-bed type.

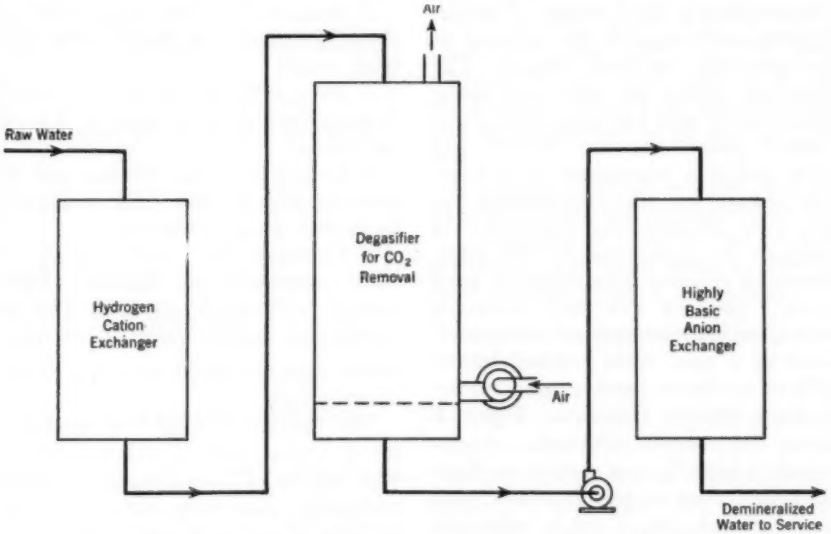

Fig. 1. Two-Step Ion-Exchange Demineralization With Silica Removal

For satisfactory silica removal, the anion exchanger employed in the last unit must be a strongly basic anion-exchange resin regenerated with sodium hydroxide.

Stability Characteristics

In view of the comparatively recent development of the modern silica-removal anion-exchange resins that are highly basic, very little information has been available on the stability in long-term silica-removal usage of the two major types of these resins. In order to accumulate data on this important point, repeated cycle tube tests were made on all of the commercially available resins of Types I and II.

In these tests, 1-in. diameter tubes containing a 20-in. bed depth of resin were set up and operated continuously, treating an influent water of the following analysis:

Cl	= 17 ppm as $CaCO_3$
SO_4	= 33 ppm as $CaCO_3$
FMA *	= 50 ppm as $CaCO_3$
CO_2	= 2–3 ppm as CO_2
SiO_2	= 16–17 ppm as SiO_2

The resins were repetitively regenerated with 6.2 lb of 5 per cent NaOH

* Free mineral acidity.

TABLE 1

Performance of Strongly Basic Anion Resins

Resin	Basicity—*kilograins/cu ft*		Ultimate Capacity—*kilograins/cu ft*		Operating Capacity*—*kilograins/cu ft*	
	Original	After Accelerated Reflux Test	Original	After Accelerated Reflux Test	Original	After 400 Cycles
Type I	13.7	14.8	22.4	22.8	9.0	9.5
Type II	22.0	11.3	26.4	29.8	14.9	7.5

* Influent: FMA = 50 ppm as $CaCO_3$; SiO_2 = 16 ppm as SiO_2; CO_2 = 2 ppm as CO_2.

solution after a fixed volume of water, approximately equal to the capacity of the resin bed, had been treated. The flow rate during the runs was maintained at 3.5 gpm per cubic foot. The contact period between NaOH and resin bed was maintained at 1 hour. The exhaustion and regeneration cycles were automatically repeated. At intervals of approximately 100 runs, measured capacity determinations were made. Four or five such measured runs were made successively to an endpoint of 1 ppm SiO_2 residual in the effluent to obtain the average capacity at these 100-run intervals. Figure 1 shows the results obtained. A decrease in capacity was noticed on Type II resins after a few hundred such runs, whereas the Type I resins remained unchanged.

Basicity

It has been common practice for many years in the authors' laboratory to determine the ability of anion resins to absorb weak acids, such as silicic acid, by measuring their "salt-splitting" ability or basicity (4). The basicity may be determined rapidly as follows:

1. Pass 270 ml of 0.75 *N* NaOH through a 16-mm column containing 40 ml of resin at a flow rate of 5 ml per minute.
2. Rinse bed as free as possible of phenolphthalein alkalinity with distilled water.
3. Pass 750 ml of 0.5 *N* NaCl through bed at flow rate of 7.5 ml per minute.
4. Collect and mix effluent, and titrate an aliquot with 0.02 *N* H_2SO_4 to methyl orange endpoint.
5. Calculate the total amount of NaCl converted to NaOH. This amount represents the salt-splitting capacity or basicity value of the resin.

These data are based on resins in the chloride form.

The basicity of fresh and used resins of Types I and II was determined. The basicity of Type I resins remained unchanged with usage, but the basicity of Type II resins dropped appreciably with usage, as indicated in Table 1.

When the first indications of a decrease in capacity on Type II resins were obtained, an accelerated test procedure was developed to determine rapidly which resin groupings were stable and which ones were unstable. It was found that, if Type II resins are refluxed in boiling water for several days while in the regenerated or hydroxyl form, the basicity of the resin drops considerably—in fact, the decrease in basicity after 72 hours of boiling is the same as that which occurs when approximately 1.5 mil gal

of water per cu ft of resin is treated in the laboratory tubes. The Type I resins that were stable in basicity in the long-term tube tests were stable in the accelerated refluxing tests. Table 1 gives the results obtained in the refluxing tests. No decrease in the basicity of the resins occurs if the resins are refluxed when in the chloride form. Furthermore, the decrease in basicity of the Type II resins occurs more rapidly if the refluxing is done in a 5 per cent NaOH solution instead of in water. The accelerated refluxing test seems to be a good guide to the stability of various types of anion exchangers. Results obtained by this test seem to agree well with those obtained by the long-term cyclic tests.

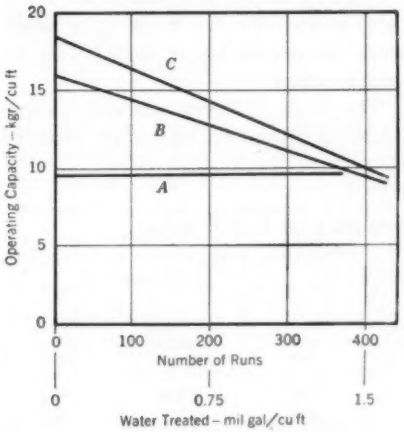

Fig. 2. Long-Term Repeated Cycle Tests

Curve A *represents Type I resin and Curves* B *and C Type II resins.*
Regenerant: 6.2 lb NaOH per cu ft
Influent: FMA = 50 ppm as $CaCO_3$
Cl = 17 ppm as $CaCO_3$
SO_4 = 33 ppm as $CaCO_3$
CO_2 = 2 ppm as CO_2
SiO_2 = 16 ppm as SiO_2

Ultimate Capacity

The ultimate capacity of anion-exchange resins can be determined as follows:

1. Pass 1,000 ml of 0.75 *N* NaOH through a 16-mm column containing 40 ml of resin, at a flow rate of 5 ml per minute.
2. Rinse bed as free as possible of phenolphthalein alkalinity with distilled water.
3. Pass 800 ml of 0.25 *N* HCl–H_2SO_4 solution (ratio 1.5 to 2.5) through bed at a flow rate of 10 ml per minute. Then pass an additional 700 ml of distilled water through the tube.
4. Collect and mix effluent and titrate an aliquot for residual acid.
5. Calculate the total amount of acid absorbed. This value leads to the total or ultimate capacity of the resin.

These data are based on resins in the chloride form.

The ultimate capacity given in Table 1 is a measure of the ability of the resins to absorb strong mineral acids.

These results can be interpreted to mean that the quaternary groups in Type II resins decompose whereas those in Type I resins do not. Furthermore, in view of the retention of ultimate capacity of Type II resins, it would seem that the quaternary groups attached to the resin matrix are converted into tertiary amine groups in the structure. Apparently the quaternary groups containing alkanol side chains are less stable than those containing only alkyl side chains.

Inasmuch as the ultimate capacity of Type II resins for strong acids is comparatively stable, it can be expected that a less noticeable decrease in the length of operating runs will

occur if the water being treated contains a high proportion of strong acids as compared to silica. A much greater decrease in capacity can be expected of waters containing a high proportion of silica. This expectation was confirmed in the authors' laboratory by making tests on two different types of influent waters with fresh and used samples of Type II resin. The data from these tests are given in Table 2.

Type II Resin

The earliest silica removal installations employing the Type II resin were those using Nalcite SAR at three demineralizing plants.* A sample of the fresh resin, unused but stored in the chloride form, which was employed in these installations, was also obtained. The basicity and ultimate-capacity results obtained are given in Table 3. It is interesting that the data on these materials that were used in the field confirm the data previously obtained in repetitive, cyclic, long-term tests in the authors' laboratory on Type II resins.

The rate of deterioration at Plant 1 and Plant 2 (Table 3) is approximately the same, even though the number of regenerations at Plant 1 was approximately 50, whereas the anion units were regenerated approximately 350 times at Plant 2. Apparently the amount of water, in gallons per cubic foot, treated by the resin is a much more important factor in the rate of deterioration.

The Type II resins are now almost exclusively used for such silica removal installations instead of the Type I resins. Because of their deterioration with usage as compared to the Type I resins, however, it is necessary that careful engineering and economic evaluations be made to determine which type of resin is better for the long-term treatment of a given water supply. When designing demineralizing plants to treat waters containing higher proportions of silica to total acids, consideration must be given to the deterioration of the Type II resins. It is important to note that as the Type II resins deteriorate, they require more

TABLE 2

Treatment of Different Waters by New and Used Type II Resins

Resin	Basicity *kilograins/cu ft*	Ultimate Capacity *kilograins/cu ft*	Influent A*		Influent B†	
			Operating Capacity *kilograins/cu ft*	Effluent SiO_2 *ppm*	Operating Capacity *kilograins/cu ft*	Effluent SiO_2 *ppm*
New	22.0	26.4	17.1	0.05	14.9	0.2
Used‡	8.3	18.3	9.7	0.05	7.5	0.3

* Influent A: FMA = 200 ppm as $CaCO_3$
SiO_2 = 16 ppm as SiO_2
CO_2 = 2 ppm as CO_2

† Influent B: FMA = 50 ppm as $CaCO_3$
SiO_2 = 16 ppm as SiO_2
CO_2 = 2 ppm as CO_2

‡ Resin treated approximately 1.5 mil gal of water per cu ft and was used for 400 runs.

* Samples of used resin from these installations and data on their field operation were obtained through the cooperation of the National Aluminate Corp., Chicago.

TABLE 3

Laboratory Evaluation of Effect of Long-Term Field Use on Type II Resin

Resin Sample	Water Treated *gal/cu ft*	Basicity *kilograins/cu ft*	Ultimate Capacity *kilograins/cu ft*	Influent A*		Influent B*	
				Operating Capacity *kilograins/cu ft*	Effluent SiO_2 *ppm*	Operating Capacity *kilograins/cu ft*	Effluent SiO *ppm*
Unused†	0	22.6	27.4	18.1	0.00	15.6	0.1
Plant 1	308,000	14.9	20.0	12.2	0.05		
Plant 2	308,000	12.8	21.0	13.1	0.05	11.3	0.4
Plant 3	601,000	9.1	17.6	11.3	0.1	8.0	0.2

* See footnotes to Table 2.
† Two years old, stored in chloride form.

and more caustic soda per kilograin of anions removed and eventually become less efficient than the Type I resins. Furthermore, units containing Type II resin, if designed on the basis of the high capacity originally available from these resins, will be undersized after the resins have been in operation for a few hundred runs. This factor may be particularly serious in automatically regenerated installations in which regeneration outage time is an important consideration.

Demineralization

It is well known that mixed-bed demineralizing produces a water having a lower electrical conductivity than can be produced by the two-step demineralizing process (5). Inasmuch as there is a simultaneous possibility that mixed-bed demineralizing may reduce the silica content of a water more than the two-step process, some interest has developed in the use of this process for producing high-pressure boiler feedwater. Tests have been run at the authors' laboratory on Type I and Type II resins employing mixed-bed and two-step demineralizing to determine if any noticeable difference in silica residuals could be observed. The results are given in Table 4. Although the mixed-bed demineralizer produced a water of 5–15 million ohms-cm resistivity—0.01–0.05 ppm electrolyte—the silica content did not seem to be lower than that obtained by the two-

TABLE 4

*Resin Characteristics in Mixed-Bed and Two-Step Demineralizing**

Resin	Anion Exchanger Regeneration Temperature—°F	Total Electrolyte by Conductivity—*ppm as NaCl*		Effluent SiO_2 *avg. ppm*		Effluent SiO_2 *min. ppm*	
		Two Step	Mixed Bed	Two Step	Mixed Bed	Two Step	Mixed Bed
Type I	70	2.0	0.01–0.05	0.055	0.06	0.035	0.045
Type II	70	3.0	0.01–0.05	0.08	0.12	0.07	0.10
	100	2.0	0.01–0.05	0.065	0.055	0.04	0.045

* Influent water: Methyl orange alkalinity = 115 ppm as $CaCO_3$
Chloride = 10 ppm as $CaCO_3$
Sulfate = 15 ppm as $CaCO_3$
Silica = 16 ppm as SiO_2

step demineralizing treatment, in which the electrical resistivity of the treated water was approximately 150,000–250,000 ohms-cm—2–3 ppm. Later tests made with warmer regenerant solutions indicate that it is possible to obtain effluent silica of 0.01 ppm SiO_2 in some runs by either two-step or mixed-bed demineralization.

Samples of treated water were collected from a large mixed-bed demineralizing installation. The influent and effluent analyses are given in Table 5.

TABLE 5

Influent and Effluent Analyses of Mixed-Bed Demineralizing Installation

	Influent ppm	*Effluent ppm*
Methyl orange alkalinity	37 as $CaCO_3$	
Chloride	7 as $CaCO_3$	
Sulfate	10 as $CaCO_3$	
Sodium	5 as $CaCO_3$	
Carbon dioxide	3 as CO_2	
Silica	15.4 as SiO_2	0.06 as SiO_2
Electrical resistivity		15,000,000 ohms-cm

The test data given in Table 5 do not seem to indicate any advantage for mixed-bed over two-step demineralizing treatment for this type of water. The amount of silica in the effluent after boiling and concentrating, a treatment similar to that which occurs in a boiler, appears to be the same by both methods. Inasmuch as the operating cost of a two-step demineralizing unit is usually lower, it may be preferred normally over the mixed-bed treatment. The authors are awaiting further tests that are to be made at a high-pressure steam power plant at which the feedwater will be treated by a newly installed mixed-bed demineralizing unit.

Conclusion

A study of the operating characteristics of Type I and Type II quaternary ammonium, highly basic, anion-exchange resins for silica removal and demineralizing indicates that the Type I resins are stable in long-term repeated cycle operation. The Type II resins decrease appreciably in operating efficiency and capacity.

These resins reduce the silica content of water to substantially the same low levels of 0.01–0.05 ppm SiO_2 in the two-step demineralizing process and in the mixed-bed demineralizing process.

Acknowledgment

The authors wish to acknowledge the able assistance of G. H. Saunders, E. Zink, and N. Arena.

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UDC 621.774.1

ASA A21.10-1952
(AWWA C110-52)

American Standard Specifications

for

SHORT-BODY CAST-IRON FITTINGS, 3 INCH TO 12 INCH, FOR 250-PSI WATER PRESSURE PLUS WATER HAMMER

PUBLISHED BY AMERICAN WATER WORKS ASSOCIATION, INC.

APPROVED BY SPONSORS

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Foreword

For a brief history of the development of standard specifications for cast-iron pipe and fittings for water, for the organization and program of the Sectional Committee (A21) on Specifications for Cast Iron Pipe and Fittings which developed the specifications contained herein, and for a description of the other specifications issued or in preparation by this sectional committee, reference should be made to the Foreword of the "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe (ASA A21.1)."

The short-body fittings described in the specifications which follow were developed to meet a growing demand for lighter, cheaper and more compact fittings than those of earlier standard specifications for bell-and-spigot fittings for water, fittings better adapted to use in distribution work in city streets congested with other utility structures. This need for more compact fittings had led to a variety of special designs by different municipalities and manufacturers.

The radical change in design raised questions of strength and hydraulic properties which were studied exhaustively by Committee A21. Strength was investigated, with numerous bursting tests in each case, by Dean M. L. Enger and Prof. W. M. Lansford of the Dept. of Theoretical and Applied Mechanics, University of Illinois (unpublished), and by the American Cast Iron Pipe Co. representing the Cast Iron Pressure Pipe Institute of the manufacturers (unpublished). Hydraulic losses, in comparison with losses in fittings of the current A.W.W.A. long-body patterns, were measured at the Cornell University Engineering Experiment Station by Prof. Ernest W. Schoder and Prof. Arthur N. Vanderlip; and an economic comparison of the short-body and the A.W.W.A. types, as they would be used in a typical distribution system, was made by Allen T. Ricketts and Thomas H. Wiggin. Both of these studies of hydraulic losses were published in Cornell University Engineering Experiment Station Bulletin No. 20, September 1935 (102 pages, $1.25). These studies, for 12-in. and smaller fittings, demonstrated not only the strength of the short-body designs, but also that these short fittings are slightly superior economically in distribution systems, considering friction losses, the cost of power for pumping, and installation costs. Longer-radius bends show somewhat smaller losses of head, but the difference is so small for usual distribution velocities, and the use of bends in distribution systems, except where space is limited, is so infrequent, that this difference may be disregarded.

Since cast-iron tees and crosses, especially those with equal outlets, defy accurate stress analysis, the designs were developed on the basis of numerous bursting tests, with allowances for water hammer, for foundry tolerance and for a loss in thickness of 0.08 in. by corrosion. These fittings are of one class only, for a static working water pressure of 250 psi plus water hammer, with or without ordinary earth loads, and with a factor of safety of about $2\frac{1}{2}$.

The designs contemplate all bell fittings. The spigots shown in Fig. 10.1 (*see* p. 1072) will be substituted for one or more bells as ordered. Fittings of the same body dimensions and laying lengths, with flange ends or ends for mechanical joints, may also be ordered under these specifications.

UDC 621.774.1

ASA A21.10-1952
(AWWA C110-52)

Proposed

American Standard Specifications for

Short-Body Cast-Iron Fittings, 3 Inch to 12 Inch, for 250-psi. Water Pressure Plus Water Hammer

This specification covers 3-in. to 12-in. short-body cast-iron fittings for water pressure of 250 psi plus water hammer as specified in the "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe" (ASA A21.1).

Sec. 10–1—Description of Fittings

Fittings shall be made with all bell ends or such other type of ends as may be agreed upon at the time of purchase. Fittings with all bell ends or with spigot ends shall accurately conform to the dimensions given in the tables accompanying and forming a part of these specifications. Fittings with other types of ends shall comply with the dimensions agreed upon but in all other respects shall fulfill the specifications hereinafter given.

Sec. 10–2—Casting of Fittings

Fittings shall be molded from accurate patterns. They shall not be stripped while sufficiently hot to be injured by subsequent cooling.

Sec. 10–3—Quality of Iron

10–3.1. All fittings shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the fittings to be cast that the iron in the fittings shall be strong, tough, resilient, of even grain and soft enough for satisfactory drilling and cutting and it shall comply with the physical specifications given in Sec. 10–14 and 10–15. The metal shall be remelted in a cupola or other suitable furnace.

10–3.2. The iron in the fittings shall not contain more than 0.90 per cent of phosphorus nor more than 0.12 per cent of sulfur. Samples for chemical analysis shall be taken by drilling completely through from skin to skin each of the acceptance test specimens; but not to exceed three specimens per heat.

Sec. 10–4—Quality of Castings

The fittings shall be smooth and free from scales, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Sec. 10–5—Foundry Records

10–5.1. *Casting.* A record of the melting and pouring temperatures of the iron shall be furnished the purchaser if requested.

10–5.2. *Chemical analyses.* Chemical analyses shall be made by the manufacturer from each heat to determine total carbon, manganese, phosphorus, sulfur and silicon; duplicate

copies of test reports shall be furnished the purchaser on request.

Sec. 10–6—Marking of Fittings

Every fitting shall have distinctly cast upon it the initials of the maker's name, and, if requested by the purchaser, figures showing the year in which it was cast. Nominal diameters of openings shall be cast on all fittings and the fraction of the circle on all bends; also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and have dimensions not less than those indicated below:

Fitting Diam. *in.*	Height of Letters *in.*	Relief *in.*
3–10	$\frac{3}{4}$	$\frac{3}{32}$
12	$1\frac{1}{4}$	$\frac{3}{32}$

The weight and the class shall be conspicuously painted in white on the inside or outside of each fitting after the coating has become hard.

Sec. 10–7—Inspection by Purchaser

10–7.1. *Definition of "Purchaser."* Wherever the word "Purchaser" is used herein it shall be understood to mean the actual purchaser of the fittings or his authorized agents acting within the scope of the duties entrusted to them.

10–7.2. *Power of purchaser to inspect.* The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, pattern work, molding, casting, coating and lining of the fittings. The forms, sizes, uniformity and conditions of all fittings herein referred to shall be subject to his inspection and approval, and he may reject any fitting which is not in conformity with the specifications or drawings. Any fitting rejected shall be marked "rejected," and any marks pertaining to the purchaser shall be chipped or erased from such fitting.

10–7.3. *Manufacturer to furnish men and materials.* The manufacturer shall provide all tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the fittings at the foundry.

10–7.4. *Report of purchaser's inspection.* The purchaser shall make written report daily at the foundry office of all fittings rejected, noting causes for rejection.

Sec. 10–8—Inspection and Certification by Manufacturer

Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made as specified, this statement to contain the results of all specified tests.

Sec. 10–9—Fittings to Be Delivered Sound

All the fittings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this regard, and any defective fitting which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for fittings found to be cracked after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting

was originally defective or damaged before acceptance. Care shall be taken in handling the fittings not to injure the coating or lining, and no material of any kind shall be placed in the fittings during transportation or at any other time after they have received the coating or lining.

Sec. 10–10—Tolerances or Maximum Permitted Variations From Standard

10–10.1. *Tolerances in diameter.* All sockets and spigots shall be tested by circular gages. All fittings shall be rejected which are defective in joint room, or which vary more than 0.12 in. from standard dimensions in the diameters of the sockets and the outside diameters of spigots.

10–10.2. *Tolerances in thickness.* No variations below the standard thickness shall be permitted for 10-in. by 10-in., 12-in. by 12-in. and 12-in. by 10-in. tees and crosses. For other fittings, variations below the standard thickness shall not be greater than those shown in the following table and note:

Nom. Diameter *in.*	Minus Tolerance *in.*
3, 4 and 6	0.10
8, 10 and 12	0.12

Note: Variations from the standard thickness of 0.02 in. in excess of the allowances above given shall be permitted for spaces not exceeding 8 in. in length in any direction.

10–10.3. *Allowable percentage of variation in weight.* No fitting shall be accepted the weight of which shall be less than the standard weight by more than 10 per cent, and no excess above the standard weight of more than 10 per cent will be paid for.

Sec. 10–11—Cleaning and Inspecting

All fittings shall have gates, fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful surface inspection and a hammer test before being coated or lined.

Sec. 10–12—Weighing

Each fitting shall be weighed and the weight and class conspicuously painted on the outside or inside of the bell or spigot end. Fittings which are to be lined with cement mortar or coated on the inside or outside, or both, with bituminous enamel or other special material shall be weighed before the application of such a lining or coating. If desired by the purchaser, fittings not lined or coated with cement mortar, bituminous enamel or other special material shall be weighed after delivery and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Unless otherwise stated in the contract, a ton shall be 2,000 lb avoirdupois.

Sec. 10–13—Linings and Exterior Coatings

Any particular lining or coating which is to be applied to the fittings shall be specified in the agreement made at the time of purchase. Separate specifications for cement-mortar lining (ASA A21.4, also known as AWWA C104) have been provided in connection with these specifications for fittings.

No fittings for water works service shall be furnished without protective coating unless specifically ordered by the purchaser.

Sec. 10–14—Test of Material

The acceptability of the iron used in the fittings shall be determined by testing bars cast from the same iron as the fittings. The observations and the computed results hereinafter required shall be recorded, and, if requested, reported to the purchaser.

Sec. 10–15—Test Bars

10–15.1. *Dimensions.* Test bars shall be 2 in. wide, 1 in. thick and not less than 26 in. long. Individual test bars may vary as much as 2 per cent from the standard width or standard thickness, or both, but the patterns and molding practice shall be such that the errors shall in general not exceed 1 per cent.

10–15.2. *Methods of casting.* The bars shall be cast vertically in well faced, dry sand molds provided with a suitable pouring basin and mounted on a suitable refractory foundation. Metal for the bars shall be obtained by using a small, heated ladle taking its metal from the main ladle from which the fittings are to be poured and after all alloys and other additional metal, except cast iron for cooling, have been added to the main ladle and become melted. The bars shall not be removed from the mold before they have cooled to 500 F.

10–15.3. *When cast and to what fittings applicable.* Except as hereinafter provided for special cases, one pair of test bars of the metal used shall be cast with iron from the first ladle, another pair with iron from the approximately middle ladle and a third pair with iron from the last ladle of iron taken during a day's run or heat, from the cupola in which the iron for the fittings is melted. If the heat lasts for more than six hours, then additional pairs of bars shall be cast at approximately uniform intervals so as to give an extra pair of bars for each three hours during which the heat lasts in excess of six hours. In case the charging of the cupola is to be changed for one or more times during the day's run or heat in order to produce a different iron, the time of taking test bars shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality; and in case such period exceeds four hours, additional pairs of bars shall be taken at such times as will provide a pair of bars for each two hours during which this special mixture is used. At least one bar from each pair shall be broken, but the manufacturer shall have the right to break both bars, in which case the better bar shall be taken as representative. Bars showing flaws in fracture may be disregarded.

10–15.4. *Test bar requirements to indicate acceptable iron.* In order that the iron shall be acceptable, the average results from the single bars representing the respective pairs of bars cast during the heat or period shall comply with the requirements hereinafter specified, and, in addition, no representative bar shall be more than 5 per cent below the minimum requirements in either corrected breaking load or corrected deflection.

10–15.5. *Method of testing.* The bars shall be broken as beams by placing them flatwise on supports 24 in. apart and applying the load at the center of the span. The breaking load and the corresponding deflection shall be observed and recorded.

10–15.6. *Correcting observed breaking loads and deflections.* The bars shall be measured at the point of ap-

plication of the load and the results corrected to standard 2-in. by 1-in. cross section by the conventional beam formula as follows:

Corrected breaking load

$$= \text{Observed breaking load} \times \frac{2}{bd^2}$$

Corrected deflection at breaking
= Observed deflection at breaking $\times d$

where b is the measured width and d is the measured depth of the bar at the point of application of the load. In the formulas above, the deflection and all dimensions are in inches.

10–15.7. ***Requirements on strength and deflection of 2-in. by 1-in. bars.*** In order to indicate acceptable metal, the corrected breaking loads and deflections of the representative 2-in. by 1-in. test bars for a given heat or period, interpreted as provided in Sec. 10–15.4 above, shall comply with the following requirements:

Minimum center breaking load:

2,300 lb

Minimum center deflection at breaking:

$0.30 + 0.0001$ (breaking load $- 2{,}300$) in.

TABLE 10.1

Weights of Short-Body Fittings

Tees and Crosses			
Nom. Diam. *in.*		Weight *lb*	
Run	Branch	Tee	Cross
3	3	80	105
4	3	100	125
4	4	105	140
6	3	140	165
6	4	150	180
6	6	160	210
8	3	200	225
8	4	210	240
8	6	220	265
8	8	240	305
10	3	280	305
10	4	290	320
10	6	300	350
10	8	320	390
10	10	370	465
12	3	365	390
12	4	375	405
12	6	385	435
12	8	405	475
12	10	460	555
12	12	485	600

Bends				
Nom. Diam. *in.*	Weight—*lb*			
	90°	45°	22½°	11¼°
3	55	50	50	50
4	70	65	65	65
6	110	100	100	100
8	165	145	145	145
10	230	200	200	200
12	305	270	270	270

Reducers		
Nom. Diam.—*in.*		Weight *lb*
Large	Small	
4	3	55
6	3	75
6	4	80
8	3	100
8	4	110
8	6	125
10	3	125
10	4	135
10	6	150
10	8	170
12	3	160
12	4	165
12	6	185
12	8	210
12	10	235

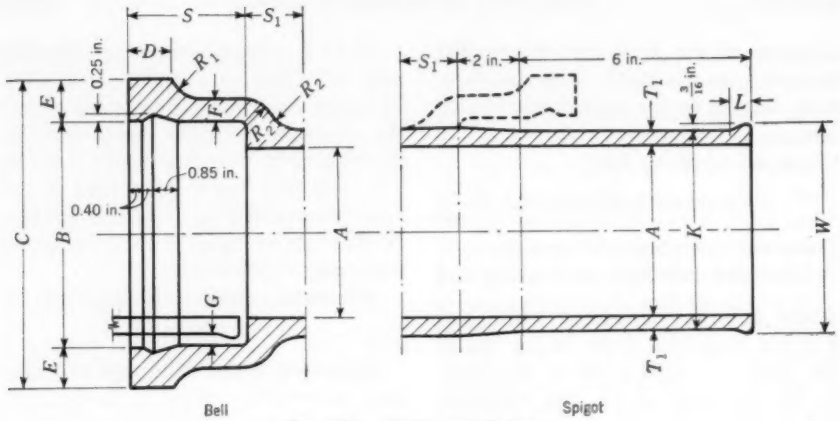


FIG. 10.1. Bells and Spigots

Bell and Spigot Dimensions

Nom. Diam in.	A	B	C	D	E	F	G	S_1	K	L	R_1*	R_2†	S	T_1	W‡
3	3.00	4.65	7.26	1.25	1.30	0.65	0.35	1.50	3.95	0.75	0.98	1.00	3.50	0.48	4.34
4	3.95	5.70	8.30	1.50	1.30	0.65	0.40	2.00	4.90	0.75	0.98	1.05	4.00	0.47	5.28
6	6.00	7.80	10.60	1.50	1.40	0.70	0.40	2.00	7.00	0.75	1.05	1.10	4.00	0.50	7.38
8	8.10	10.00	13.00	1.50	1.50	0.75	0.41	2.00	9.18	1.00	1.12	1.16	4.00	0.54	9.56
10	10.04	12.10	15.30	1.50	1.60	0.80	0.42	2.00	11.25	1.00	1.20	1.22	4.00	0.60	11.63
12	12.00	14.20	17.60	1.50	1.70	0.85	0.42	2.00	13.35	1.00	1.28	1.27	4.00	0.68	13.73

* $R_1 = 1.5(E - F)$. † $R_2 = F + G$. ‡ $W = K + 0.38$.

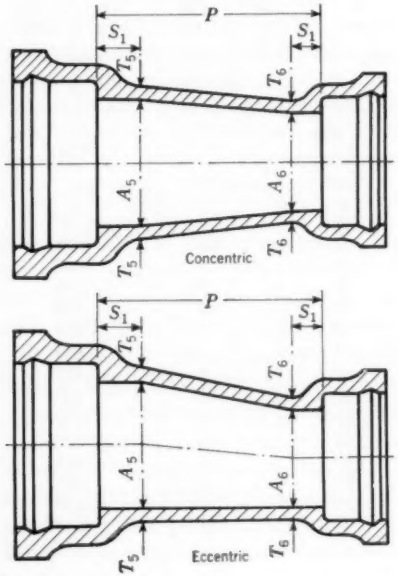


FIG. 10.2. Concentric and Eccentric Reducers

*Standard Short-Body Reducers**

Size in.	A_5	A_6	T_5	T_6	P
4×3	3.96	3.00	0.52	0.48	7.00
6×3	6.00	3.00	0.55	0.48	9.00
6×4	6.00	3.96	0.55	0.52	9.00
8×3	8.10	3.00	0.60	0.48	11.00
8×4	8.10	3.96	0.60	0.52	11.00
8×6	8.10	6.00	0.60	0.55	11.00
10×3	10.04	3.00	0.68	0.48	12.00
10×4	10.04	3.96	0.68	0.52	12.00
10×6	10.04	6.00	0.68	0.55	12.00
10×8	10.04	8.10	0.68	0.60	12.00
12×3	12.00	3.00	0.75	0.48	14.00
12×4	12.00	3.96	0.75	0.52	14.00
12×6	12.00	6.00	0.75	0.55	14.00
12×8	12.00	8.10	0.75	0.60	14.00
12×10	12.00	10.04	0.75	0.68	14.00

* S_1 equals 1.5 in. for 3-in. size; S_1 equals 2.0 in. for 4-in. through 12-in. size. For bell and spigot dimensions, see Fig. 10.1.

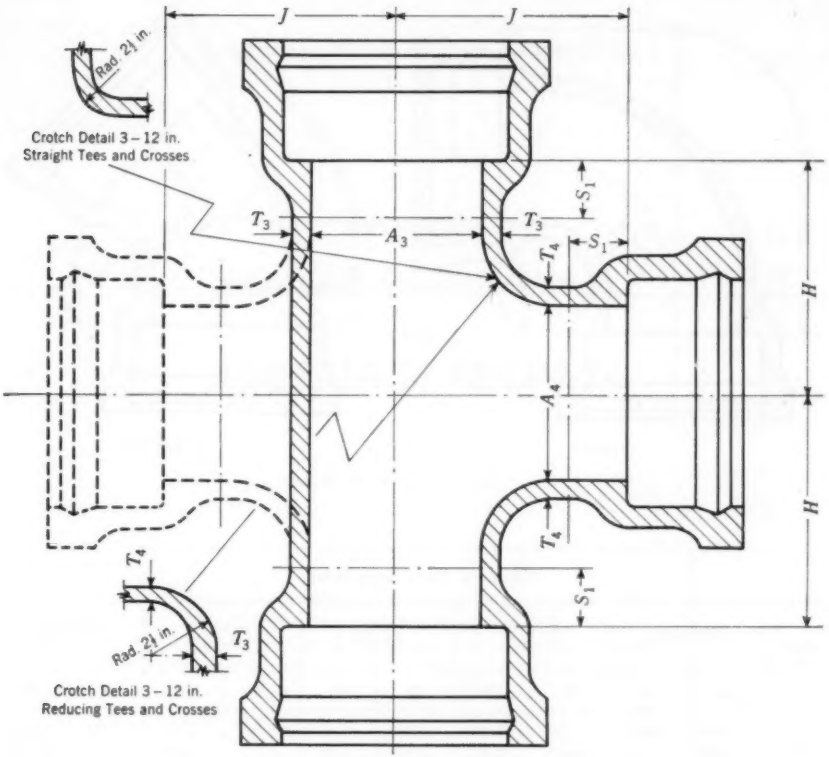


FIG. 10.3. Tees and Crosses

*Standard Short-Body Tees and Crosses**

Size in.	A_3	A_4	H	J	T_3	T_4	Size in.	A_3	A_4	H	J	T_3	T_4
3×3	3.00	3.00	5.5	5.5	0.48	0.48	10×4	10.04	3.96	11.00	11.00	0.68	0.52
4×3	3.96	3.00	6.5	6.5	0.52	0.48	10×6	10.04	6.00	11.00	11.00	0.68	0.55
4×4	3.96	3.96	6.5	6.5	0.52	0.52	10×8	10.04	8.10	11.00	11.00	0.68	0.60
6×3	6.00	3.00	8.0	8.0	0.55	0.48	10×10	10.04	10.04	11.00	11.00	0.80	0.80
6×4	6.00	3.96	8.0	8.0	0.55	0.52	12×3	12.00	3.00	12.00	12.00	0.75	0.48
6×6	6.00	6.00	8.0	8.0	0.55	0.55	12×4	12.00	3.96	12.00	12.00	0.75	0.52
8×3	8.10	3.00	9.0	9.0	0.60	0.48	12×6	12.00	6.00	12.00	12.00	0.75	0.55
8×4	8.10	3.96	9.0	9.0	0.60	0.52	12×8	12.00	8.10	12.00	12.00	0.75	0.60
8×6	8.10	6.00	9.0	9.0	0.60	0.55	12×10	12.00	10.04	12.00	12.00	0.87	0.80
8×8	8.10	8.10	9.0	9.0	0.60	0.60	12×12	12.00	12.00	12.00	12.00	0.87	0.87
10×3	10.04	3.00	11.00	11.00	0.68	0.48							

* S_1 equals 1.5 in. for 3-in. size; S_1 equals 2.0 in. for 4-in. through 12-in. size. For bell and spigot dimensions, see Fig. 10.1.

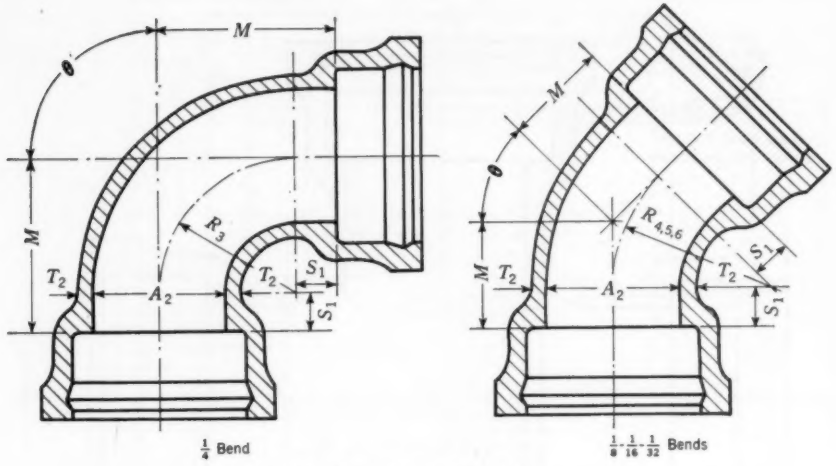


FIG. 10.4. Short-Body Bends

*Standard Short-Body Bends**

Size *in.*	All Bends		¼ Bend $\theta = 90°$		⅛ Bend $\theta = 45°$		1/16 Bend $\theta = 22\frac{1}{2}°$		1/32 Bend $\theta = 11\frac{1}{4}°$	
	A_2	T_2	M	R_3	M	R_4	M	R_5	M	R_6
3	3.00	0.48	5.50	4.00	3.00	3.62	3.00	7.56	3.00	15.25
4	3.96	0.52	6.50	4.50	4.00	4.81	4.00	10.06	4.00	20.31
6	6.00	0.55	8.00	6.00	5.00	7.25	5.00	15.06	5.00	30.50
8	8.10	0.60	9.00	7.00	5.50	8.44	5.50	17.63	5.50	35.50
10	10.04	0.68	11.00	9.00	6.50	10.88	6.50	22.62	6.50	45.69
12	12.00	0.75	12.00	10.00	7.50	13.25	7.50	27.62	7.50	55.81

* S_1 equals 1.5 in. for 3-in. size; S_1 equals 2.0 in. for 4-in. through 12-in. size. For bell and spigot dimensions see Fig. 10.1.

AWWA B403-52T

American Water Works Association

Tentative

Standard Specifications

for

ALUMINUM SULFATE

These "Tentative Standard Specifications for Aluminum Sulfate" are based upon the best known experience and are intended for use under normal conditions. They are not designed for use under all conditions and the advisability of use of the material herein specified in any water treatment plant must be subjected to review by the chemist or engineer responsible for operations in the locality concerned.

Approved by the AWWA Board of Directors as "Tentative,"
Aug. 21, 1952

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

Tentative

Standard Specifications for Aluminum Sulfate

Part A—Material Specifications

Sec. 1A—Scope

These specifications cover aluminum sulfate, either purified or unpurified and in lump or ground form, for use in the purification of municipal and industrial water supplies. The specifications are intended for use in connection with Part B (Sampling, Inspection, Packing, and Marking) and Part C (Testing Methods) of this document.

Sec. 2A—Definition

Aluminum sulfate is the basic product of the reaction between sulfuric acid and a mineral deposit rich in aluminum, such as bauxite.

Sec. 3A—Sampling

Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 4A—Methods of Testing

The laboratory examination shall be carried on in accordance with Part C (Testing Methods) of this document.

Sec. 5A—Impurities

The aluminum sulfate supplied under these specifications shall contain no soluble mineral or organic substances in quantities capable of producing deleterious or injurious effects upon public health or water quality.

Sec. 6A—Rejection

6A.1. Notice of dissatisfaction with a shipment, based on the specifications, must be in the hands of the consignor within ten days after receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within five days of notice of the complaint. Upon receipt of the request for a retest, the consignee shall forward to the consignor one of the sealed samples (2B.6). In the event that the results obtained by the consignor, on retesting, do not agree with the results obtained by the consignee, the other sealed sample shall be forwarded, unopened, for analysis to a laboratory agreed upon by both parties. The results of the referee shall be accepted as final and the cost of the referee analysis shall be paid by the party whose results show the greatest discrepancy from the referee analysis.

6A.2. On the basis of the retest or the referee test, the consignor may remove the material from the premises of the consignee or a price adjustment may be agreed upon by the consignor and consignee.

Sec. 7A—Size

7A.1. Lump aluminum sulfate shall range in size from not less than $\frac{1}{2}$ in. to not more than 3 in.

7A.2. Ground aluminum sulfate for use in dry-feeding machines shall be of such size that not less than 90 per cent shall pass a National Bureau of Standards No. 10 sieve having 9.21 openings per linear inch, and 100 per cent shall pass a National Bureau of Standards No. 4 sieve having 4.22 openings per linear inch.

Sec. 8A—Content of Alumina

Aluminum sulfate shall contain not less than 17 per cent available water-soluble alumina (Al_2O_3).

Sec. 9A—Basicity

There shall be at least 0.3 per cent by weight of the water-soluble alumina (Al_2O_3) in excess of the amount theoretically required to combine with the sulfur trioxide (SO_3) present, exclusive of that combined with the foreign sulfates.

Sec. 10A—Iron

The total water-soluble iron (Fe_2O_3) content of aluminum sulfate (Sec. 8A) shall be no more than 0.75 per cent.

NOTE: There are a number of plants where aluminum sulfate with a higher iron content can be used without increasing the iron content of the treated water. If a plant test shows that aluminum sulfate having a higher iron content can be used satisfactorily and it is agreeable to the purchaser, aluminum sulfate with a higher iron content may be furnished.

Sec. 11A—Insoluble Material

11A.1. In unpurified aluminum sulfate the insoluble matter shall not exceed 10 per cent.

11A.2. In purified aluminum sulfate the insoluble matter shall not exceed 0.5 per cent.

Part B—Sampling, Inspection, Packing, and Marking

Sec. 1B—Scope

These procedures for the sampling, inspection, packing, weighing, and marking of aluminum sulfate are intended for use in connection with Part A (Material Specifications) and Part C (Testing Methods) of this document.

Sec. 2B—Sampling

2B.1. Samples shall be taken at the point of destination.

2B.2. If the aluminum sulfate is handled by conveyor or elevator, a mechanical sampling arrangement may be used.

2B.3. If the aluminum sulfate is packaged, 5 per cent of the packages shall be sampled. No sample shall be taken from a broken package.

2B.4. In sampling lump material in cars in bulk, sampling points must be selected uniformly over the surface of the bulk material. A minimum of ten points at regular intervals shall be selected. At least 7 lb (approximately a shovelful) shall be taken at each point. Care should be taken to include a proportionate amount of lumps and fines.

2B.5. Ground aluminum sulfate may be sampled using a sampling tube which is at least $\frac{3}{4}$ in. in diameter, from carload shipments in bulk or from packages.

2B.6. The gross sample, weighing at least 50–70 lb, shall be crushed, if necessary, and mixed thoroughly and divided by quartering, to provide three 1-lb samples. They shall be sealed in airtight, moistureproof glass containers. Each sample container shall be labeled to identify it and the label shall be signed by the sampler.

Sec. 3B—Packing and Shipping

3B.1. Aluminum sulfate, either ground or lump, may be shipped in bulk, in 100-lb multiwall paper bags, in 200-lb textile or burlap bags, or in 400-lb barrels or fiber drums.

3B.2. The net weight of packages shall not deviate from the recorded

weight by more than ± 2.5 per cent. If exception is taken to the weight of the material received, it shall be based on a certified unit weight of not less than 10 per cent of the packages shipped and selected at random from the entire shipment.

Sec. 4B—Marking

Each shipment of material shall carry with it some means of identification. Each package shall have marked legibly thereon the net weight of the contents, the name of the manufacturer, and a brand name, if any. The package may bear also the following statement: "Guaranteed by (name of manufacturer) to meet the specifications of the American Water Works Association for aluminum sulfate," and may be marked "Purified" or "Unpurified."

Part C—Testing Methods

Sec. 1C—Scope

These methods for the examination of aluminum sulfate are intended for use in connection with Part A (Material Specifications) and Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 2C—Sampling

2C.1. Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

2C.2. The 1-lb sample delivered to the laboratory shall be quartered to approximately 100 g, and this amount reduced by mechanical grinding, or grinding rapidly in a mortar by hand, to such size that all of it passes a 30-mesh sieve. After thorough mixing, this sample shall be stored in an air-tight glass container. The necessary amounts shall be weighed from the glass container rapidly to avoid change in moisture content.

2C.3. The laboratory examination of the sample shall be completed within five working days after receipt of the shipment.

Sec. 3C—Insoluble Matter

Dissolve 5 g of the sample of unpurified, or 20 g of the sample of purified, aluminum sulfate in approximately 150 ml of hot distilled water. After stirring for a few minutes, filter through a prepared Gooch crucible which has been previously dried at 100–105 C and weighed. Wash the residue with hot water with at least ten separate washings or until the residue is free from sulfates. Dry in an oven to constant weight at 100–105 C and calculate the percentage of insoluble matter according to the following formula:

$$\frac{\text{Weight of insoluble residue}}{\text{Weight of sample}} \times 100 = \text{per cent insoluble matter}$$

Sec. 4C—Total Soluble Alumina

4C.1—*Reagents:*

4C.1.1. Concentrated hydrochloric acid.

4C.1.2. Concentrated nitric acid.

4C.1.3. Ammonium hydroxide diluted 1:1 with distilled water.

4C.1.4. Methyl red indicator (dissolve 1 g in 500 ml of neutral 95 per cent alcohol).

4C.1.5. Washing solution (dissolve 20 g of ammonium chloride in 1 liter of distilled water).

4C.2—*Procedure:*

4C.2.1. Transfer the filtrate from the insoluble matter to a 1-liter volu-

metric flask, cool to room temperature, dilute to the mark with distilled water, and mix thoroughly. (If ferric iron is to be determined in this solution, it should be done at once.)

4C.2.2. Measure duplicate portions, each equivalent to 0.5 g of original sample, into 400-ml beakers and dilute to approximately 200 ml with distilled water.

4C.2.3. Add 5 g of ammonium chloride and stir until dissolved.

4C.2.4. Add 2 ml of concentrated hydrochloric acid and four drops of concentrated nitric acid, and boil gently for a few minutes to oxidize the iron.

4C.2.5. Place porous quantitative filter papers (Whatman No. 41 or equivalent) in the funnels, keep the washing solution hot, and bring the samples to near boiling.

4C.2.6. Add the methyl red indicator and then add the diluted ammonium hydroxide slowly until a precipitate starts to form. Continue the addition of the ammonium hydroxide, dropwise, until the first appearance of a yellow color.

4C.2.7. Boil the samples for 1 min, or until the color just begins to turn faint pink; long boiling or standing before filtering causes the precipitate to become slimy, which prolongs filtration.

4C.2.8. Filter immediately, keeping the filter papers nearly full to expedite filtration. Using the washing solution, transfer all of the precipitate from the beakers to the papers and wash the precipitate into the apex of the paper. Continue washing with at least ten separate washings or until the precipitate is free from sulfates. Save the filtrate for determination of foreign sulfates (*see* note following Sec. 4C.3).

4C.2.9. Place the filter paper and contents, apex up, in a weighed platinum crucible and ignite over an ordinary burner very carefully, starting with a very low flame and gradually increasing it to full heat in approximately an hour. If preferred, the filter paper may be folded carefully over the wet precipitate, placed inverted in the crucible and dried in an oven at approximately 100 C before igniting over the burner. After all the carbon is burned off, heat over a blast or Meker burner or place in a muffle furnace at 1,000 C for 1 hour. Place in a desiccator until cool.

4C.2.10. Weigh as rapidly as possible and then ignite uncovered with the blast or Meker burner or replace in a muffle furnace at 1,000 C for another 5 min. After the covered crucible has been cooled in a desiccator, place all the weights on the balance pan before removing the crucible from the desiccator to avoid prolonged exposure of the crucible contents to the atmosphere while weighing. Repeat the 5-min ignitions with the blast or Meker burner or in a muffle furnace until constant weight is obtained. The weight of the residue represents the weight of the aluminum and iron oxides.

4C.3—*Calculation:*

$$\frac{\text{Weight of residue} - \text{total weight of soluble iron as } Fe_2O_3}{\text{Weight of sample}} \times 100 = \text{per cent alumina } (Al_2O_3).$$

NOTE: If sulfates other than those of iron and aluminum are present, a double precipitation is necessary for accurate results. The washed precipitate on the filter should be dissolved in warm hydrochloric acid, the solution diluted to 200 ml, and the precipitation repeated in exactly the same manner after dissolving 5 g of ammonium chloride in the liquid.

It is not necessary to use nitric acid before the second precipitation.

Sec. 5C—Total Water-soluble Iron

5C.1—*Reagents:*

5C.1.1. Iron-free sulfuric acid diluted 1:3 with distilled water.

5C.1.2. Phosphoric acid 25 per cent.

5C.1.3. Diphenylamine barium sulfonate 0.3 per cent.

5C.1.4. Approximately 0.1*N* potassium dichromate prepared by dissolving 4.903 g of the cp oven-dried salt in 1 liter of distilled water.

5C.1.5. 10–12-mesh, iron-free granulated zinc.

5C.1.6. Saturated solution of mercuric chloride, concentrated hydrochloric acid, and stannous chloride. Dissolve 5 g of stannous chloride in 10 ml of concentrated hydrochloric acid and dilute to 50 ml with distilled water. Add a few pieces of metallic tin.

5C.2—*Procedure:*

5C.2.1. Dissolve 10 g of the sample in approximately 100 ml of hot distilled water. After stirring for a few minutes, digest on the hot plate just below the boiling point for 30 min and filter through a No. 42 Whatman filter paper catching the filtrate in a 250-ml Erlenmeyer flask. Wash the residue with hot water with at least ten separate washings or until the residue is free from sulfates.

5C.2.2. Allow the solution to stand a few hours before standardization. Standardize against Sibley iron ore furnished by the National Bureau of Standards using either of the reduction methods which follow.

5C.2.2.1. *Zinc reduction method.* To the solution in the Erlenmeyer flask add exactly 1 g of granulated zinc and 20 ml of diluted sulfuric acid and close the mouth of the flask with a Bunsen valve. Heat gently. The zinc should not be dissolved in less than 25 min. After the zinc is dissolved, boil gently for 5 min and cool to room temperature with the Bunsen valve in place. Rinse the Bunsen valve with distilled water, add 30 ml of 25 per cent phosphoric acid (5C.1.2) and 7 to 10 drops of diphenylamine barium sulfonate indicator (5C.1.3). The total volume of the solution should be between 150 and 200 ml.

5C.2.2.2. *Stannous chloride reduction method.* To the solution in the Erlenmeyer flask (5C.2.1) add 10 ml of hydrochloric acid and heat to boiling. Add the stannous chloride solution (5C.1.6) dropwise until the last trace of greenish yellow color disappears. Then add an additional drop in excess to assure complete reduction. Cool to 20 C, add 60 ml of distilled water, and then pour in all at once 20 ml of saturated mercuric chloride solution (5C.1.6) with agitation to insure instantaneous mixing. If the white, silky precipitate is dark in color, it indicates too great an excess of stannous chloride and the entire procedure must be repeated on a new sample. Add 30 ml of 25 per cent phosphoric acid solution and 7 to 10 drops of diphenylamine barium sulfonate indicator. The volume of the solution should be between 150 and 200 ml.

5C.2.3. Titration (following either of the reduction methods). Titrate with 0.1*N* potassium dichromate (5C.1.4). Near the endpoint the green color of the solution deepens to a blue green, or, in the presence of large amounts of iron, to a grayish blue; after this point the dichromate solution is added dropwise until the color changes to an intense violet blue. A blank determination should be made on the reagents.

The blank plus 0.05 ml (indicator correction) should be subtracted from the volume of the dichromate used.

NOTE: The ceric sulfate method in which orthophenanthrolin is used as an indicator may be substituted for the dichromate method if agreed upon by the manufacturer and the purchaser. If this method is employed, the exact procedure used should be agreed upon by both parties.

5C.3—*Calculation:*

$$\frac{\text{Net ml of } 0.1N\ K_2Cr_2O_7 \times 0.005584}{\text{Weight of sample}} \times 100$$

= per cent water-soluble iron (Fe).

5C.4. In the zinc reduction method it is important that the zinc be weighed accurately in order that the same amount will be in the blank as in the determination. The dichromate method has considerable advantage over the permanganate method because the color produced does not fade. The dichromate method permits back titration with the standard ferrous solution. Organic substances and zinc, aluminum, manganese, nickel, cobalt, and chromium do not interfere. Copper in larger quantities than 1 mg gives lower results. Trivalent arsenic gives higher results.

Sec. 6C—Ferric Iron

6C.1—*Reagents:*

6C.1.1. Potassium thiocyanate (KCNS) or ammonium thiocyanate (NH_4CNS), 1 per cent in distilled water.

6C.1.2. Standard iron solution. To prepare, dissolve 5.000 g of ferrous ammonium sulfate (pure, fresh crystals of $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$) in 50 ml of water and add potassium permanganate ($KMnO_4$) solution drop by drop until the iron is completely oxidized as shown by a permanent pink liter. One milliliter of this solution color. Cool and dilute with distilled water to 1 liter. One milliliter of this solution equals 0.001 g of ferric oxide (Fe_2O_3).

6C.2.1. Measure an amount of a fresh, filtered solution of aluminum sulfate equivalent to 1 g of the sample into a 100-ml Nessler tube. (Solution prepared according to 5C.2.1 may be used if it is taken immediately after filtration.) Add, cautiously, 5 ml of concentrated sulfuric acid, cool, and add 20 ml of potassium thiocyanate or ammonium thiocyanate solution, dilute to the 100-ml mark with distilled water, and mix thoroughly.

6C.2.2. In another similar 100-ml Nessler tube, place approximately 50 ml of distilled water, 5 ml of concentrated sulfuric acid, and 20 ml of potassium thiocyanate or ammonium thiocyanate solution, and fill the tube nearly to the 100-ml mark with distilled water.

6C.2.3. Titrate the blank immediately with the standard iron solution until the red color it contains is equal in intensity to that of the aluminum sulfate solution.

6C.3—*Calculation:*

$$\frac{\text{ml of standard iron solution} \times 0.001}{\text{Weight of sample}} \times 100$$

= per cent of ferric iron as Fe_2O_3.

Sec. 7C—Ferrous Iron

Subtract the ferric iron (Sec. 6C) as ferric oxide (Fe_2O_3) from the total iron (Sec. 5C) as Fe_2O_3. The difference is the ferrous iron in terms of Fe_2O_3. Multiply this figure by 0.90 to obtain the ferrous iron in terms of ferrous oxide (FeO).

Sec. 8C—Foreign Sulfates

8C.1. *Procedure:*

8C.1.1. Evaporate the filtrate, or the combined filtrates if a double precipitation was used (4C.2.8 or note following 4C.3) to approximately one-half volume. Make slightly acid with sulfuric acid and transfer to a platinum or porcelain dish of approximately 100-ml capacity which has been previously ignited, cooled, and weighed.

8C.1.2. Evaporate as far as possible on the steam bath, and transfer to a hot plate and gradually raise the temperature until all of the free acid * and most of the ammonium salts have been volatilized. Do not heat the dish hotter than a dull red.

8C.1.3. Cool, moisten the residue with a few drops of water, and evaporate to dryness. Ignite the residue at a temperature not exceeding 500 C until it comes to constant weight. The residue represents foreign sulfates.

8C.2—*Calculation:*

$$\frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100$$

= per cent foreign sulfates.

8C.3. The sulfur trioxide (SO_3) in the residue may be determined as prescribed for sulfur trioxide (*see* Sec. 9C).

Sec. 9C—Sulfur Trioxide

9C.1—*Reagents:*

9C.1.1. Hydrochloric acid (HCl), 2 per cent by weight in distilled water.

9C.1.2. Barium chloride ($BaCl_2$), 10 per cent by weight in distilled water.

9C.2—*Procedure:*

9C.2.1. Measure an amount of the filtrate from the determination of the insoluble matter (4C.2.1) equivalent to 1 g of the original sample of aluminum sulfate into a 400-ml beaker. Add 300 ml of water and 2 ml of 2 per cent hydrochloric acid and heat to boiling.

9C.2.2. Add 15 ml of the barium chloride solution drop by drop with rapid stirring, keeping the solution to which it is added near the boiling point. Digest for not less than 2 hr on the steam bath or hot plate.

9C.2.3. Filter through a tight quantitative filter paper and wash with hot distilled water until a 25-ml portion of the filtrate shows no more than a slight opalescence with silver nitrate.

9C.2.4. Place the filter paper containing the precipitate in a weighed platinum crucible and heat slowly over a low flame to char the filter paper without allowing it to catch fire. After complete charring, ignite to constant weight over an ordinary burner with the crucible uncovered, cooling between weighings in a desiccator.

NOTE: If the charring of the paper is too rapid, some of the barium sulfate ($BaSO_4$) may be reduced to barium sulfide (BaS). In that event, moisten the precipitate with concentrated sulfuric acid, heat very carefully to drive off the acid, and finally ignite.

9C.3—*Calculation:*

$$\frac{\text{Weight of } BaSO_4 \text{ residue} \times 0.343}{\text{Weight of sample}} \times 100$$

= per cent of sulfur trioxide (SO_3).

* Extreme care should be exercised that all of the sulfuric acid added is completely volatilized. If the sulfuric acid is not entirely removed, the final result will be in error. The temperature of the dish should be controlled so that all of the sulfuric acid is driven off but should not be high enough to decompose the sulfates.

Sec. 10C—Basicity and Free Acid

10C.1. *Calculation method.* Calculate the ferrous and ferric iron respectively to ferrous sulfate ($FeSO_4$) and ferric sulfate [$Fe_2(SO_4)_3$]. Subtract the amount of sulfur trioxide (SO_3) in the iron sulfates and in the foreign sulfates from the total SO_3, and calculate the remaining SO_3 to aluminum sulfate [$Al_2(SO_4)_3$]. If the total soluble alumina (Al_2O_3) is in excess of the amount required for the SO_3, report the difference as basic alumina. If the amount of SO_3, exclusive of that combined with the foreign sulfates, is in excess of that required for the iron and the alumina, calculate the excess to sulfuric acid (H_2SO_4) and report as free sulfuric acid.

10C.1.1. Ferrous iron as ferrous sulfate. Per cent ferrous oxide (Sec. 7C) × 2.114 = per cent ferrous sulfate.

10C.1.2. Ferric iron as ferric sulfate. Per cent ferric oxide (Sec. 6C.3) × 2.504 = per cent ferric sulfate.

10C.1.3. Ferrous sulfate as sulfur trioxide. Per cent ferrous sulfate × 0.527 = per cent sulfur trioxide (A).

10C.1.4. Ferric sulfate as sulfur trioxide. Per cent ferric sulfate × 0.6007 = per cent sulfur trioxide (B).

10C.1.5. Per cent sulfur trioxide in foreign sulfates (Sec. 8C) (C).

10C.1.6. Total sulfur trioxide (Sec. 9C.3) (D).

10C.1.7. Total sulfur trioxide (D) − sulfur trioxide ($A + B + C$) = per cent sulfur trioxide combined with aluminum sulfate (E).

10C.1.8. Per cent alumina (Sec. 4C.3) × 3.3562 = per cent aluminum sulfate.

10C.1.9. Per cent sulfur trioxide (E) × 1.4244 = per cent aluminum sulfate (F).

10C.1.10. Per cent aluminum sulfate (F) × 0.29797 = per cent alumina (G).

10C.1.11. Per cent alumina (Sec. 4C.3) − per cent alumina (G) = per cent basic alumina.

10C.1.12. Total sulfur trioxide (D) − sulfur trioxide (C) = per cent sulfur trioxide exclusive of that combined with foreign sulfates (H).

10C.1.13. Per cent sulfur trioxide (H) − per cent sulfur trioxide ($E + A + B$) = per cent sulfur trioxide in excess (J).

10C.1.14. Per cent sulfur trioxide in excess (J) × 1.2250 = per cent free sulfuric acid.

10C.2. *Direct method.*

A direct method to determine basicity or acidity is given herewith. The method is based on the decomposition of aluminum salts by an excess of neutral potassium fluoride (KF) to form two stable compounds neutral to phenolphthalein, whereas any free acid remains unaltered.

10C.2.1.—*Reagents:*

(a) 0.1 per cent alcoholic phenolphthalein solution.

(b) Potassium fluoride solution. Dissolve 1,000 g of pure potassium fluoride in 1,200 ml of hot carbon dioxide–free distilled water, add 0.5 ml phenolphthalein solution [10C.2.1(a)] and neutralize with potassium hydroxide or sulfuric acid (or hydrofluoric acid) until 1 ml of solution in 10 ml of distilled water (carbon dioxide–free) shows a faint pink color. Filter out any insoluble matter without washing and dilute to 2,000 ml with carbon dioxide–free water. If stored for long periods, keep in a plastic bottle or a bottle coated inside with wax.

(c) 0.5N sulfuric acid and 0.5N potassium hydroxide. Standardize the

alkali against the acid in approximately 40 ml of distilled water to which 10 ml of potassium fluoride solution [10C.2.1(b)] has been added using phenolphthalein [10C.2.1(a)] as indicator.

10C.2.2. *Procedure.* Use a solution of aluminum sulfate equivalent to approximately 3.5 g of sample or dissolve that amount in approximately 100 ml of distilled water and heat to boiling. Add to hot solution 10 ml of 0.5*N* sulfuric acid. Cool to room temperature. Add 18–20 ml of potassium fluoride solution and 0.5 ml phenolphthalein solution. Titrate with 0.5*N* potassium hydroxide drop by drop until a slight pink color persists for 1 min. The titration shows whether the sample is basic or acid.

10C.2.3—*Calculation:*

$$\frac{(\text{ml of } 0.5N\ H_2SO_4 - \text{ml of } 0.5N\ \text{KOH}) \times 0.0085 \times 100}{\text{Weight of sample}} = \text{per cent free alumina } (Al_2O_3).$$

$$\frac{(\text{ml of } 0.5N\ \text{KOH} - \text{ml of } 0.5N\ H_2SO_4) \times 0.0245 \times 100}{\text{Weight of sample}} = \text{per cent free sulfuric acid } (H_2SO_4).$$

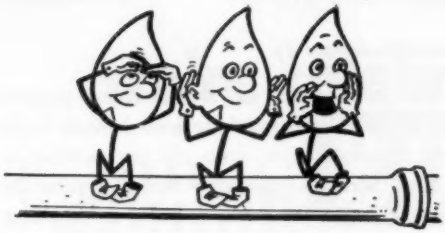
Basic alumina: when the potassium hydroxide back titration is less than the amount of sulfuric acid added.

Free acid: when the potassium hydroxide back titration is more than the amount of sulfuric acid added.

Neutral: if potassium hydroxide back titration is equal to sulfuric acid added.

NOTE

These "Tentative Standard Specifications for Aluminum Sulfate" were prepared under the direction of J. E. Kerslake for the Water Purification Division, AWWA. The specifications were approved by the Executive Committee of the Water Purification Division and by the Water Works Practice Committee, and received the approval of the Association's Board of Directors on Aug. 21, 1952. They were also submitted for review to producers and consumers of the materials involved, whose comments were then considered by Paul Tamer, acting as referee. These "Tentative Standard Specifications for Aluminum Sulfate" supersede the "Specifications for Chemicals Used in Water Purification—Sulphate of Alumina," published in *Water Works Practice Manual,* American Water Works Assn., New York (1925), and "Emergency Alternate Specifications for Sulfate of Alumina" adopted by the AWWA, June 25, 1942, and published in the July 1942 JOURNAL.



Percolation and Runoff

Election facts and figures hot off the polls ain't exactly our forte. As a matter of fact, about all we can report about the 1952 stew from our October vantage point is that the election is now in the bag—duffel or otherwise. One ballot on which we can give you the scoop, however, is that of March 30–March 30, 1881, that is, when AWWA members attending the first annual meeting in Engineers Hall, St. Louis, selected the site of their second convention. The facts, as extracted from the practically pumpkinized minutes of that meeting,* speak for themselves:

On motion, the Association selected the place holding the next annual meeting. On motion, a viva voce vote be taken to ascertain the views of the members; upon the call of the roll the choice stood thus:

Cincinnati, Ohio	4	Chicago, Ill.	8
Columbus, Ohio	6	Indianapolis, Ind.	7
Terre Haute, Ind.	1	Leavenworth, Kan.	1
Davenport, Ia.	1		

On motion of J. W. Harrison, the three cities receiving the highest number of votes, viz., Chicago, Columbus and Cincinnati, were placed in nomination. Mr. Watts was continued as teller and proceeded to ballot with the following result: Columbus, 12 votes; Chicago, 12 votes.

There being more votes than members present, a new ballot was ordered, and each member was instructed to sign his name to his ballot. Second ballot: Columbus, 12 votes; Chicago, 9 votes.

On motion, the vote for Columbus to be declared unanimous was carried.

Lest you feel slightly injured in the antiquity, we ought to admitigate that teller Watts was actually an unconcerned St. Louisan, that Columbus wasn't and hadn't a member at that time, and that Indianapolis finally did get elected in 1896. And a more than 100 per cent vote has at least some advantage over our present 50 per cent performances.

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* *Constitution and By-Laws of the American Water Works Ass'n Together With Proceedings of First Annual Session Held at St. Louis, Missouri, March 29, 30 and 31, 1881.* Hannibal Printing Co., Hannibal, Mo. (1881). Presented to AWWA by Member Benjamin L. Smith, Albany, N.Y., September 25, 1952.

(*Continued on page 2*)

(*Continued from page 1*)

Dowsing has finally been put in its place as "a folk-ritual pattern which has been extraordinarily persistent in rural American culture." It was Dr. Evon E. Vogt, Harvard anthropologist, who did the putting in a recent article in *Scientific Monthly* and who did it in terms of what he calls a "dynamic conception of ritual." Ritual patterns such as dowsing, he pointed out, "develop as a response to emotional anxiety and cognitive frustration in a situation of uncertainty; but ritual patterns come to have both 'functional' and 'dysfunctional' aspects for the continuing existence of a society as the patterns are elaborated and developed in terms of the selective value-orientation of a given culture." All of which is merely an anthropological way of saying that dowsing is the patent medicine taken to cure the painful uncertainty of not knowing where to dig—ineffective but comforting. And until good medicine, in the form of sound geological advice, is readily available, the tonic will be taken wherever a good well isn't a sure thing.

Actually, since the dowser's fee in the small rural community is usually little more than the cost of a few bottles of patent medicine and since records * indicate that he doesn't interfere too seriously with the development of satisfactory supplies of water, he probably is worth the peace of mind he affords. There would be no need for us to get exercised, either, about the "elaboration of the pattern" represented by the welding rod ouija (described in July P&R p. 10 and Aug. P&R p. 68) except that it represents a substitution of patent medicine for good medicine that is readily available. As a matter of fact, every report that the service trucks of still another water utility have been equipped with "dowser pipe finders" gives us a twinge of retrogression. What bothers us isn't the cost of the rods, isn't even the cost of digging possibly pipeless holes, it's the loss of face and of some measure, however infinitesimal, of public confidence that certainly must follow such a retreat from scientific professionalism. How'd you like to catch your doctor brewing herbs in some cemetery under the light of a cross-eyed moon?

Hazen-Williams hydraulic slide rules are being imported from Germany and distributed in this country by Roger I. Eby, 1014 Merchants Exchange Bldg., San Francisco 4, Calif. The price is $12.00, postpaid, with about two months required for delivery.

* An investigation by the Water Conservation and Irrigation Commission covering all wells (3,428) drilled in New South Wales between 1918 and 1939 indicated that 83.9 per cent of 1,675 undowsed wells were completely successful whereas only 70.4 per cent of the 1,753 dowsed wells were. Also it was shown that 14.7 per cent of the dowsed, and only 7.5 per cent of the undowsed, wells turned out to be completely dry.

(*Continued on page 4*)

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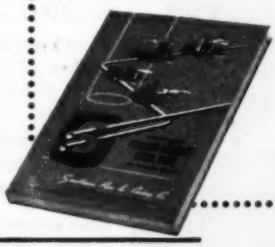

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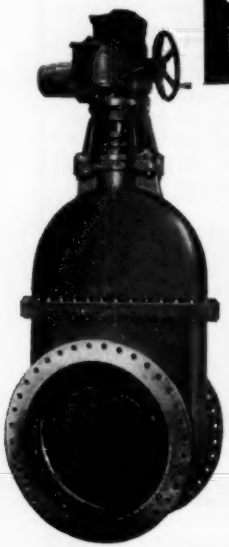
(Continued from page 2)

Easy-goism, introduced last August (P&R p. 2) with the description of the Pendleton, Ore., "your bill is your check" system, may be pushed one step further any day now at Toledo, Ohio. At any rate, the city manager there is promoting the installation of drive-in cashier windows on the civic center mall to permit "easy payment of water bills." What next but to make the water bill a regular pay deduction and, thus, forgotten, but not gone?

Apparently unconverted to the new cause is the Niagara Falls, N.Y., water department which, in installing its new billing system last month, not only made payment no easier but scared half its customers half to death by eliminating the decimal point. The unspeechless among them threatened to drive the department staff dotty by keeping its telephone ringing constantly with demands for an explanation of "my bill for $781."

Great as may be its advantages in reducing delinquency in payments, extreme easy-goism, particularly of the Pendleton type, may actually represent a step backward in public relations. After all, making the water bill as little noticed as the water service already is, seems a much less satisfactory solution than of calling maximum attention to both as the best proof that water service is a good buy!

(Continued on page 6)



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(*Continued from page 4*)

Research on desalting of sea water has been started by the Bureau of Reclamation on the strength of a $2,000,000 authorization of the Congress. The bill had originally called for a $25,000,000 study and pilot-plant demonstration of rainmaking and sea water distillation. With the rainmaking and pilot plant features deleted, and actual appropriations so far limited to $125,000 of the $2,000,000 total, the research will go forward, but in lower gear.

C. H. Atkins, chief of the Div. of Sanitation, Public Health Service, has been assigned as chief sanitary engineer of the Public Health Mission to India under the TCA (Point 4) program. He is being succeeded in the sanitation division by assistant chief Leonard M. Board.

After attending the State Dept. Foreign Service School, Atkins leaves for New Delhi, where he will also serve as assistant chief of mission, chief sanitary engineer for the government of India, and visiting professor of sanitary engineering at the All-India Hygiene Inst.

Gadgets on the modern automobile are by way of driving drivers to distraction as well as to financial ruin, but there is just one more we'd like to see installed as standard equipment on every car. It hasn't been invented yet, but basically it's water—water as a quick and easy cigarette extinguisher. If not that, of course, there is always the Emery technique, but that may be found rather uncomfortable for the chain smoker since it involves knocking over a fire hydrant to soak the smoker as well as the smoke. Actually Clyde H. Emery of Lebanon, N.H., for whom the technique was named when he accidentally discovered it in an unsuccessful attempt to throw a cigarette out of his window, doesn't recommend his method as economical either, and will probably be first in line to purchase the "Dash Splash" smoke-soaker as soon as someone dreams it up. We, of course, will provide the water!

"Naturally!" is Duke Murden's answer to the fluoridation problem at Portsmouth, Va. And not only does he not pay for it, he makes it pay—naturally. The secret—Murden's Mixture, a combination of a high fluoride ground water with the regular surface supply to yield a water with the optimum content of fluorides. No worries about "adding rat poison to the water" or "spending money to treat the whole supply when only a very small amount is ingested." No chemicals, no chemical feeders or other equipment, no personnel hazards, just an auxiliary supply that provides more than 2 mgd of well water that costs less than the surface supply because it does not require treatment and that, thus, actually reduces the overall cost of operating the system. Not a panacea, perhaps, but a possibility.

(*Continued on page 8*)

just a reminder that -

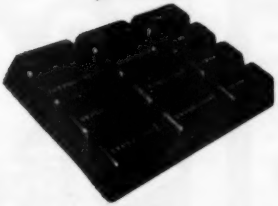
A pipeline is no stronger than its joints.

POWDER OR PIGS—WITH FIBREX MAKE PERFECT JOINTS

Working Samples on Request.

HYDRO-TITE (POWDER)

HYDRO-TITE (LITTLEPIGS)

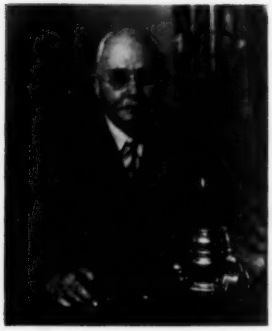


FIBREX (REELS)

HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office 90 Church Street, New York General Offices and Works W. Medford Station, Boston, Mass.

(Continued from page 6)



George B. Bassett, founder and chairman of the board of Buffalo Meter Co., was honored at a dinner celebrating the firm's 60th anniversary on October 1. Among the events of the evening was the presentation to the 91-year-old designer and industrialist (shown, at left, with an early and a present-day model of his meter) of his certificate of Life Membership in AWWA. As he joined the Association in April 1909, he is among the oldest of its members in point of service, and boasts nearly a half-century of affiliation.

A microbiology division has been established in the Mellon Inst. of Industrial Research, Pittsburgh, and will be available for specialized advice and short-time studies to industry. The division will be headed by William W. Leathen.

(Continued on page 10)

SIMPLICITY of American Meters PAYS OFF for You!

Buffalo AMERICAN Meters are simply designed, with fewer working parts—save money for you through lower maintenance and replacement costs. Write for details.

BUFFALO METER COMPANY
2914 Main Street
Buffalo 14, New York

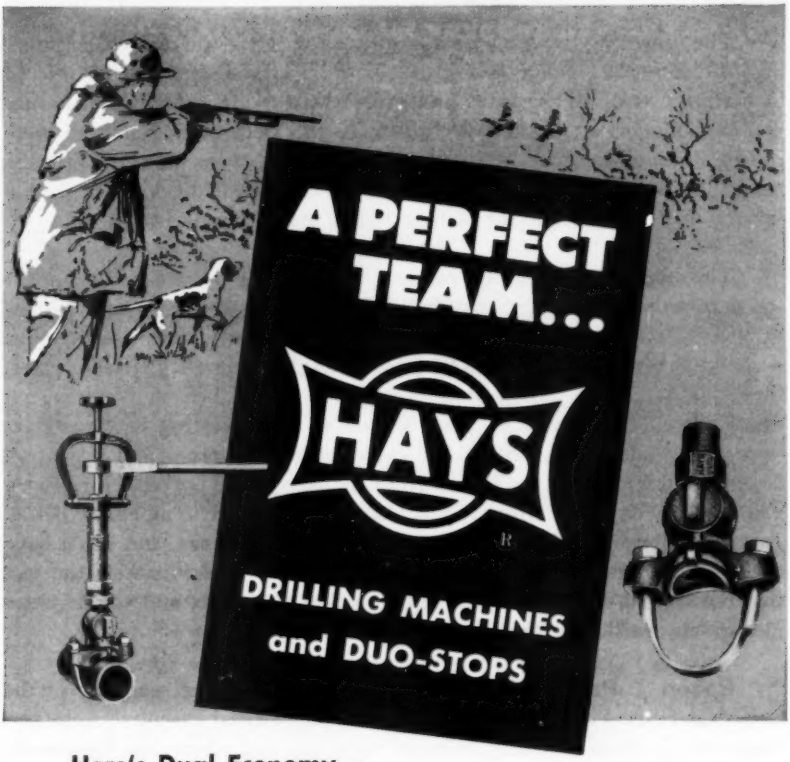
On their reputation for performance, Kupferle Fire Hydrants deserve consideration for any installation.

KUPFERLE

Full lines for public and private installations.

Send for Specification sheets.

JOHN C. KUPFERLE FOUNDRY CO.
ST. LOUIS



Here's Dual Economy—

HAYS DUO-STOP . . . Corporation Stop and saddle combined for installation on small service lines.

HAYS Main Drilling Machine . . . an economical device for drilling the main, through the Duo-Stop or other types of Corporation Stops.

These are only two of the hundreds of items in the complete Water Works line made by HAYS.

Write for literature or ask "The Man from Hays"

HAYS

Water Works Products

HAYS MANUFACTURING CO.
ERIE, PA.

(*Continued from page 8*)

The water wagon became a band wagon in the township committeeman campaign at Hillside, N.J., last month, when the nominees discovered that a promise of better water promised a better vote. The only one unhappy about the whole thing seemed to be the Democratic nominee, who, having invented the idea, resented the preemption of his plank. With the voters, we would think the more who climbed aboard the merrier if only he who was carried in on the plank could be made to walk it.

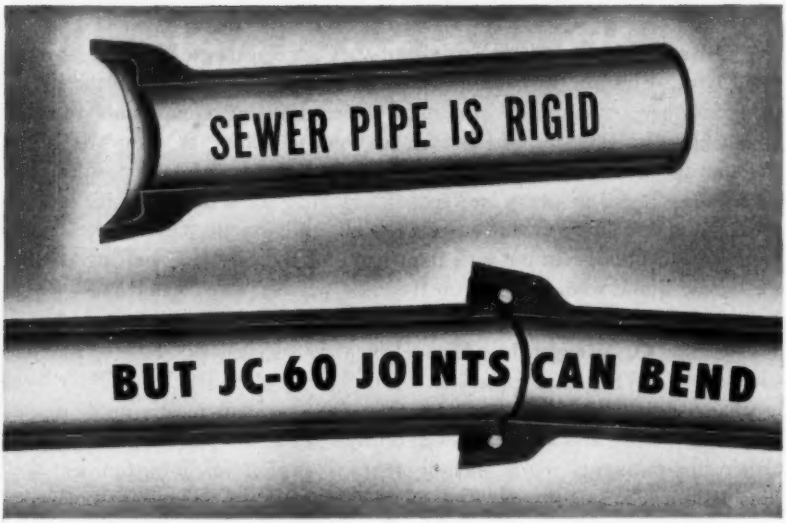
The beer bier better be ready. As a matter of fact if the current trend continues long there may be nothing to bury but the burp. First, in Britain, only a few months ago (June P&R p. 14), scientists found a way to dehydrate beer to 25 per cent its normal volume. Just add water, they said, and you'll have a brew as good as new. Then, in Belgium, not much later, a biochemist hit upon a method of desiccating beer to tablet form. Just add water, alcohol, and carbon dioxide, he said, and you won't be able to tell whether the brew's from the box or the barrel. Finally, in Seattle every day, just ordinary folks have reduced beer to an empty bottle. Just add water, malt, hops, yeast, and corn sugar, they say, and you'll have a home brew reminiscent of Prohibition. Add to these disasters the fact that bootlegging is increasing as rapidly as the liquor tax and you'll get an idea of why we'll soon be saying: "Just drink water!"

Robert J. Painter, formerly treasurer and assistant secretary of the American Society of Testing Materials, has been elected executive secretary. Raymond E. Hess, formerly technical secretary and editor, has been made associate executive secretary.

Stanley M. Dore, assistant chief engineer for the Allegheny County Sanitary Authority of Pittsburgh, Pa., and previously Karl R. Kennison's deputy chief engineer at the Metropolitan District Water Supply Commission, Boston, Mass., has joined his former chief at the New York City Board of Water Supply. He will assist chief engineer Kennison in the capacity of deputy chief engineer of the Design Dept. It will be a busy year for Dore—he has also just been elected president of the New England Water Works Assn.

H. H. Cooper Jr., ground water district engineer for the Geological Survey in northern Florida, has been appointed staff engineer in the Ground-Water Branch of the survey's Water Resources Div., with headquarters in Tallahassee, Fla. He will act as adviser to the district offices in the Carolinas, Georgia, Florida, and Alabama, in addition to maintaining his former responsibilities until a successor is chosen.

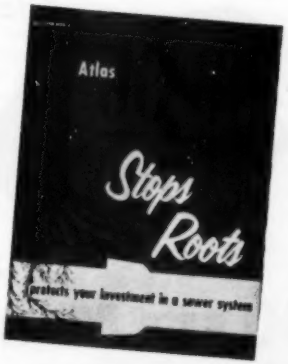
(*Continued on page 12*)



Joints poured with ATLAS JC-60® are stronger than the sewer pipe itself, yet flexible enough to withstand normal settling. Even on low temperature deflection tests, JC-60 joints have taken a 15° bend without *any* rupture of the leakproof bond. Compare these assuring results with other jointing compounds. Notice that the JC-60 compound holds . . . while others may fail.

Advantages of JC-60 such as positive resistance to root penetration, flexibility and others save you money . . . both in negligible maintenance and minimum pumping costs throughout years of service.

Get the complete facts.
Write for your copy of new Bulletin M20-3.



ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN PENNSYLVANIA
HOUSTON 1, TEXAS

ATLAS JOINTING COMPOUNDS
. . . a permanent bond

(Continued from page 10)

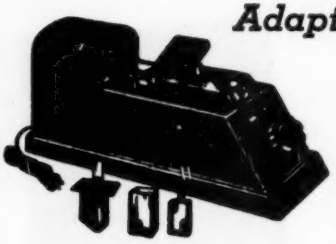
Oil and water may not mix, but they sure seem to be getting mixed up of late. First, in the columns of *Popular Science* as well as in the literature of the Department of Agriculture, we read of the "Octa-Gane" injector which makes it possible to burn up to 1 gal of water for every 10 gal of gasoline in your automobile motor and to get more and better mileage in so doing. Then, in every newspaper and magazine, we find that one of those fabulous Texans who has eleven oil wells on his farm makes more money from his one water well than from all the oil. It's getting so that we hardly know what to pour on troubled what.

James O. Wright has been elected to succeed his father, the late Charles W. Wright, as president of Badger Meter Mfg. Co. His twin brother William simultaneously became vice-president in charge of manufacturing. Both brothers have been officers of the company for many years. Other appointments made include that of Joseph E. Johnston as vice-president in charge of sales and member of the board, and P. J. Berner as secretary-treasurer and member of both the board and the Executive Committee.

(Continued on page 14)

KLETT SUMMERSON
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis

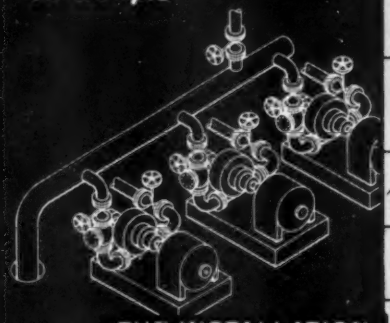


Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET · NEW YORK, N. Y.

Can You Trust Your Checks to Hold Like This?

...on Water Pumps, for example



THE INSTALLATION

VALVE SERVICE RATINGS

SUITABILITY:	Working smoothly-no complaints
FEATURES:	OK for either horizontal or upward flow
MAINTENANCE COST:	None-no maintenance needed to date
SERVICE LIFE:	Now better than other checks used
OPERATING RESULTS:	No water or head loss
PRICE:	In line with other makes
AVAILABILITY:	Stock item-Crane product

Crane Iron Body Swing Check Valves in 8-inch vertical lines on water pumps supplying a large eastern paper mill.

THE HISTORY

The mill depends on these pumps for all water. It could take no risk with loss of head here. Regularly, the check valves formerly on the pumps were replaced, but only to be found leaking between pumping cycles a few months later.

That's why the mill switched to Crane Check Valves. Now in service more than a year, they completely stopped all water loss and trouble with checks on the pumps. They proved Crane Quality means better valves—greater dependability, bigger value. More of these checks were put on a battery of suction pumps with the same results.

THE VALVE

Crane No. 373, 125-Pound Iron Body Swing Check Valves, brass trimmed. The long life and high seating efficiency of these checks, in 2 to 8-in. sizes, is in large part due to the Crane patented flexible disc-hinge design. Double spring mounting eliminates lost motion between parts, yet permits true, full contact of disc and seat at every closure. Also serves to absorb seating shock under backflow pressure. See your Crane Catalog or Crane Representative for full details.

The Complete Crane Line Meets All Valve Needs. That's Why More Crane Valves Are Used Than Any Other Make!

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

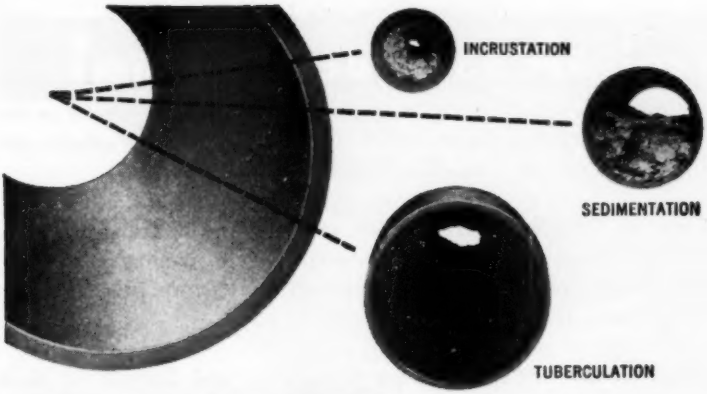
(*Continued from page 12*)

Philadelphia water is fast becoming more notorious than Philadelphia lawyers ever were. It has already reached a point where it can evoke a broadcast of sympathy by the city of comradely love for the city of brotherly love, and, brother, that means taste and odor. In the politalk of Radio Moscow, of course, the problem is not melon taste and just plain pew, but the activities of Mellon and Pew and the rest of the "financial group . . . in the robbing and plundering of working classes and detention of progressive workers." Fortunately for Gerry Arnold, he hadn't arrived at Philadelphia when all this imperialisticism was going on, or, for that matter, when the sympathy was spread, but we're looking to him to pass on the ill repute to some place like Cincinnati where even the natives sometimes claim to detect a slight flavor of catfish perspiration, or maybe even to Moscow, where they call it caviar.

The old rope trick—not the skyhook one, but the one by which water is raised from a well without a bucket—was recently resurrected at the University of Illinois. Using a clothesline, a six-inch pulley rotated at 1,750 rpm by a ¼-hp motor, and a second pulley in the water source, the two hydraulics professors who dug the trick out of a textbook were able to raise 12 gpm 25 ft. "Since there seems to be no limit on the height of the lift," says *Popular Science*, "they think it could do almost any job, such as raising water for livestock." Or, perhaps, lowering livestock to water. Anyway, if water works men don't buy the idea immediately, we'll know it's because they haven't been given enough rope.

C. Fred Gurnham has been appointed head of the Dept. of Chemical Engineering at Michigan State College, East Lansing. He is a member of the President's National Technical Task Committee for industrial wastes and was previously head of the chemical engineering department at Tufts College.

(*Continued on page 16*)



NATIONAL KNOW-HOW PAYS!

National knows how to work quickly reducing supplementary labor costs and service interruptions.

National knows how to clean the difficult jobs, including hard incrustations, unusual obstructions and pipes of unusually large or small diameter.

National knows how to clean long runs with a minimum number of pipe entries.

National knows how to avoid trouble, such as can occur from improper provision for drainage of flush water from large mains or from the use of excessive pressures.

National knows how to clean so thoroughly that restoration of 95% of the original pipe capacity is guaranteed.

National Know-How comes from over 40 years of experience cleaning water mains.

Write or call today for information and prices.

NATIONAL WATER MAIN CLEANING COMPANY

50 Church Street • New York, N. Y.

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ATLANTA, GA; 333 Candler Building • BERKELEY, CALIF; 905 Grayson Street • DECATUR, GA; P. O. Box 385 • BOSTON, MASS; 115 Peterboro Street • CHICAGO; 122 So. Michigan Avenue • ERIE, PA; 439 E. 6th Street • FLANDREAU, S.D; 315 N. Crescent Street • KANSAS CITY, MO; 406 Merchandise Mart and 2201 Grand Avenue • LITTLE FALLS, N.J; BOX 91 • LOS ANGELES; 5075 Santa Fe Avenue • MINNEAPOLIS, MINN; 200 Lumber Exchange Building • OMAHA, NEBR; 3812 Castellar Street • RICHMOND, VA; 210 E. Franklin Street • SALT LAKE CITY; 149-151 W. Second South Street • SIGNAL MOUNTAIN, TENNESSEE; 204 Slayton Street • DALLAS, TEXAS; 6617 Snider Plaza • MONTREAL, CANADA; 2028 Union Avenue • WINNIPEG, CANADA; 576 Wall Street • HAVANA, CUBA; Lawrence H. Daniels, P. O. Box 531 • SAN JUAN, PUERTO RICO; Luis F. Caratini, Apartado 2184.

(Continued from page 14)

Formosa, for most of us, has been a sort of king-size Devil's Island at the outermost reaches of our indignation. What with the news these days it's time we realized that there are more than 140 water works on the island, that the Formosan water works journal is in its third volume and going strong. What price water we'll endeavor to discover.

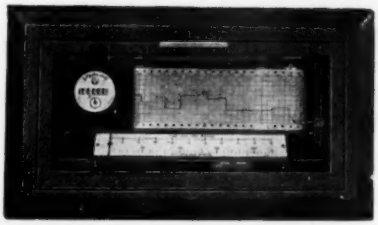
George N. Schoonmaker having retired from the Toledo, Ohio, consulting firm of Jones, Henry & Schoonmaker, the remaining partners—Thomas B. Henry and Leon G. Williams—will carry on the practice under the name of Jones, Henry & Williams.

Roland S. Burlingame, Joseph C. Lawler, and Darrell A. Root have been admitted to partnership in the consulting firm of Camp, Dresser & McKee of Boston.

R. G. Baker has been appointed regional sales representative of De-Laval Steam Turbine Co. for the Detroit, Minneapolis, and Chicago area, with headquarters in the last city.

(Continued on page 18)

SPARLING
Main-Line Meters



Accurate main-line measurement is the key to efficient operation

Descriptive Bulletin 311 comes on request

SPARLING METER COMPANY

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CINCINNATI 2 ..... 626 Broadway
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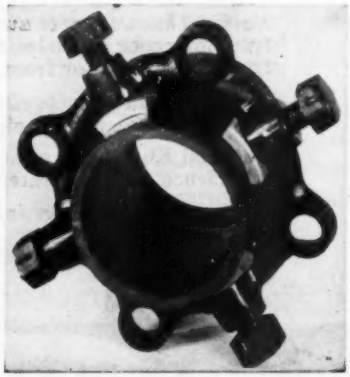
BOSTON 8 ..... 6 Beacon Street
SEATTLE 1 ..... 1932 First Avenue
DALLAS 1 ..... 726 Reserve Loan Life Bldg.
ATLANTA 3 ..... 66 Luckie St. N. W.
KANSAS CITY 6 ..... 6 East 11th St.



ANCHORED CLAMP for MECHANICAL JOINTS

Also CI-60 charcoal cast iron bolts for mechanical joints; bell-joint Leak Clamps and Gasket Sealer Compound.

Write for information

H. Y. CARSON COMPANY
1221 Pinson St. Birmingham, Ala.

Impact Insurance Against

1—LOSS OF FIRE PROTECTION.

2—EXCAVATION AND PAVEMENT REPLACEMENT.

3—COSTLY REPAIRS INVOLVING MAJOR HYDRANT COMPONENTS.

4—FLOODING.

The Smith Protectop Hydrant is designed to permit rapid return to service at minimum cost when a Hydrant is damaged as a result of a traffic accident.

The Protectop Hydrant Standpipe and Valve Stem are equipped with *Special Couplings* located just above the ground. The Couplings withstand operating pressures and ordinary impact with an ample factor of safety. Under excessive impact occasioned by traffic accidents the Couplings fracture at the design points thus minimizing the damage and permitting speedy return to service at low cost.

All Smith Hydrants are equipped with *Compression Type* Valves which definitely eliminate flooding since the line pressure holds the Valve against its seat in the closed position.

Write for details.

38

FIRE HYDRANTS · VALVES · SINCE 1896

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

(Continued from page 16)

Little-Jack-Hornerism, female variety, made the headlines in South Bend, Ind., last month when Mrs. Louise Johnson put in her thumb and pulled out something ten-tentacled and terrifying. It was into the clogged lavatory drain that Mrs. Johnson extended a digit and came up with an octopus. "Squid," said the Notre Dame professor of zoology called in on the case. "Squid, edible, habitat Mediterranean," and, fortunately for the South Bend water utility, "will not survive in fresh water." Of course this one did wrap itself around Mrs. Johnson's thumb. . . .

L. A. Dixon Jr. has been appointed vice-president of the Meter and Valve Div. of Rockwell Mfg. Co., having been promoted from the post of assistant vice-president.

Phenolphooey seems to be a special problem in Michigan. Past headaches from the glue on paper cups and from the castor-oil base jointing compound used by a plumber have Bob Hansen at Mt. Clemens so jumpy that the taste of sour cream in his morning coffee is enough to precipitate a full-scale investigation of the system. And now George Hazey at Wyandotte has joined the party, tracing the sharp and repulsive chlorphenol type taste in the residence of one of his customers to a fiber insulating coupling used to prevent galvanic action in the household plumbing. Who next will be nipped in the bud?

Fred Stuart Jr. has joined his father as chemical engineer for the Stuart Corp., in which capacity it is expected he will work on problems of industrial waste treatment as well as municipal water supply. He had previously been employed by the Universal Oil Products Co.

An automatic throwover panel has been designed by the Control Dept. of General Electric Co. to transfer essential electric circuits to standby power sources when the regular supply is interrupted. In addition to their switching function, the units also turn on the auxiliary power generator. For closer control, a time-delay relay can be incorporated in the circuit to avoid premature switching during momentary current interruptions, and a voltage-sensitive relay is also available to insure switching whenever the voltage drops below a previously selected point.

A new valve position indicator for filter operating tables has been designed by Builders-Providence, Inc., to eliminate electrical, water, or air connections. Entirely mechanical in operation, the system depends on a monel metal bead chain enclosed in a copper tubing sheath. Installation economies over the conventional cable and pulley arrangement are claimed.

(Continued on page 76)

ON CALL TO SERVE YOU

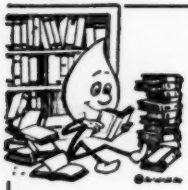
WALLACE & TIERNAN FLUORIDATORS

Wallace & Tiernan is on call to give you the same complete service on fluoridators that it has given on other chemical feed equipment for the past thirty-nine years. When your community is considering the addition of fluorides, W&T Representatives are prepared to provide you with data on the types of chemicals which may be used, the selection of the point of application, the types of equipment available for feeding fluorides, and other aspects of fluoridation. After the decision to fluoridate has been made, W&T can provide accurate, dependable Fluoridators—especially designed for the exacting requirements of fluoridation. W&T's nationwide, factory trained, service staff is prepared to give prompt service on all W&T Fluoridators to ensure the continuous operation of the fluoridation process. W&T is On Call to serve you—see your W&T Representative for additional information.

Series A-635
Gravimetric Fluoridator

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

S-76



The Reading Meter

Lake Erie Drainage Basin: *Summary report on water pollution. Water Pollution Series, No. 11; Public Health Service Pub. No. 119. Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 42 pp.; paperbound; free*

The smallest of the fifteen basins into which the country has been divided for purposes of administering the Federal Water Pollution Control Act illustrates the complexity and interstate character of watersheds. The area of the basin is slightly more than 14,000 square miles, or less than a third that of the state of Pennsylvania, and yet it comprises sections—however small—of Michigan, Indiana, Ohio, Pennsylvania, and New York. About 53 of the 59 per cent of the population inadequately served by treatment facilities is centered in three large cities in Ohio, and facilities are being planned or constructed in all three to help remedy the situation.

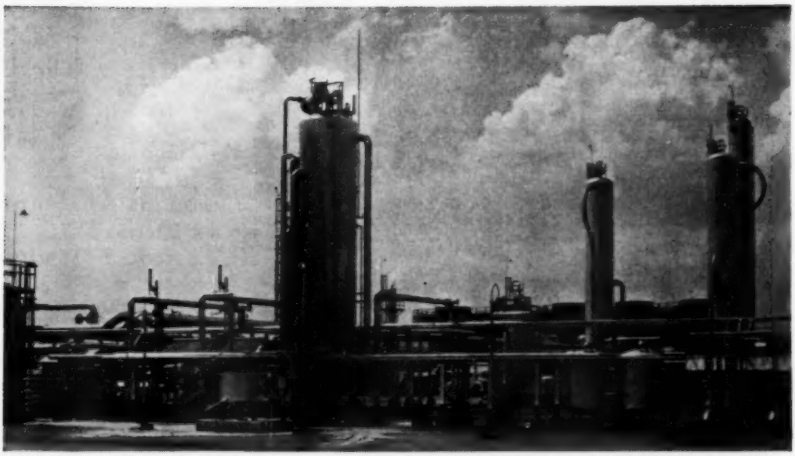
Ohio River Drainage Basin: *Summary report on water pollution. Water Pollution Series, No. 12; Public Health Service Pub. No. 136. Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 178 pp.; paperbound; free*

Acid mine drainage poses a serious threat to practically all water uses in the Ohio River basin, but extension of research, continued public support, and further work by the Ohio River Valley Water Sanitation Commission promise an energetic attack on the evil. Regulation of low flows is also suggested to alleviate pollution.

Western Great Lakes Drainage Basin: *Summary report on water pollution. Water Pollution Series, No. 14; Public Health Service Pub. No. 143. Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 52 pp.; paperbound; free*

The three largest of the Great Lakes—Superior, Huron, and Michigan—give to this region a fresh water supply without parallel. As elsewhere, however, the end-products of civilization are threatening nature's gifts; and, although damage has so far been acute only in localized areas, the states have been active in taking control measures.

(*Continued on page 78*)



NORTH COWDEN GASOLINE PLANT near Odessa, Texas, operated by Stanolind Oil and Gas Company. Here Worthington Water Softeners protect boilers from scale-forming deposits.

Worthington softeners protect this plant's boilers 10 ways

In this case, it's a hot-process softener to remove scale-forming deposits from boiler feedwater.

Let's examine this gasoline plant installation and see how it gives boilers "maximum" protection:

1. *Feed water is softened* by a hot-lime soda system.
2. *Selective deaeration* for operation on make-up only, condensate only, or both.
3. *Non-scaling direct-contact vent condenser* heats and vents treated make-up.
4. *Tubular vent condenser vents condensate.*
5. *Oxygen contamination of feedwater avoided* by last-step deaeration.
6. *Stainless steel deaerating elements.*
7. *Uniform and efficient deaeration* during wide load swings.
8. *Filter backwashing* with clean, hot, chemically inert water without velocity change through the softening zone.
9. *Proportionate sludge removal.*
10. *Uniformly proportionate chemical feed.*

Before you buy, investigate Worthington Water Softening Systems thoroughly. Tell us the service conditions, and get our recommendations in terms of dollars and benefits. Write Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Water Treating Section, Harrison, New Jersey.

A1-A

Worthington Makes More of the Equipment for ALL Types of Water Conditioning Systems

WORTHINGTON

Water Conditioning

The Forgotten Man

To the Editor:

In your September "First Lady" write-up on the three generations of water works men in Mrs. W. S. Cramer's family, you failed to mention that husband Willard S. was an AWWA President and a Diven Medalist. He was for many years the Manager of the Lexington, Ky., Water Co. Mrs. Cramer was also an authority on the breeding of fine horses.

P. S. WILSON

325 Washington St.
Glen Ridge, N.J., Sept. 20, 1952

We counted W. S., but were apparently so wrapped up in the lady we didn't recognize him. Fine horses, but finer men.—ED.

What's Wrong

To the Editor:

Won't you do something about that word "Correction," which sometimes occurs in the table of contents of the JOURNAL? There is a useless word for you!

The purpose of the "Contents," I suppose, is to aid the busy reader in learning whether or not he wants to read the articles. But this word tells him nothing. He doesn't know what is being corrected or how. If you had said this, for example, in the contents of the July issue:

Correction to Michigan Section
Distribution Standards 616

then the line would be useful. As it is you have either to ignore all such corrections or check up on a lot in which you are not interested.

ARTHUR B. MORRILL

Cons. Engr.
National Inst. of San. Works
Caracas, Venezuela, Oct. 8, 1952

Reader Morrill is correct, of course, and we will mend our ways. Only reason we can figure for our oversight is that we always know all too well where the error lies.—ED.

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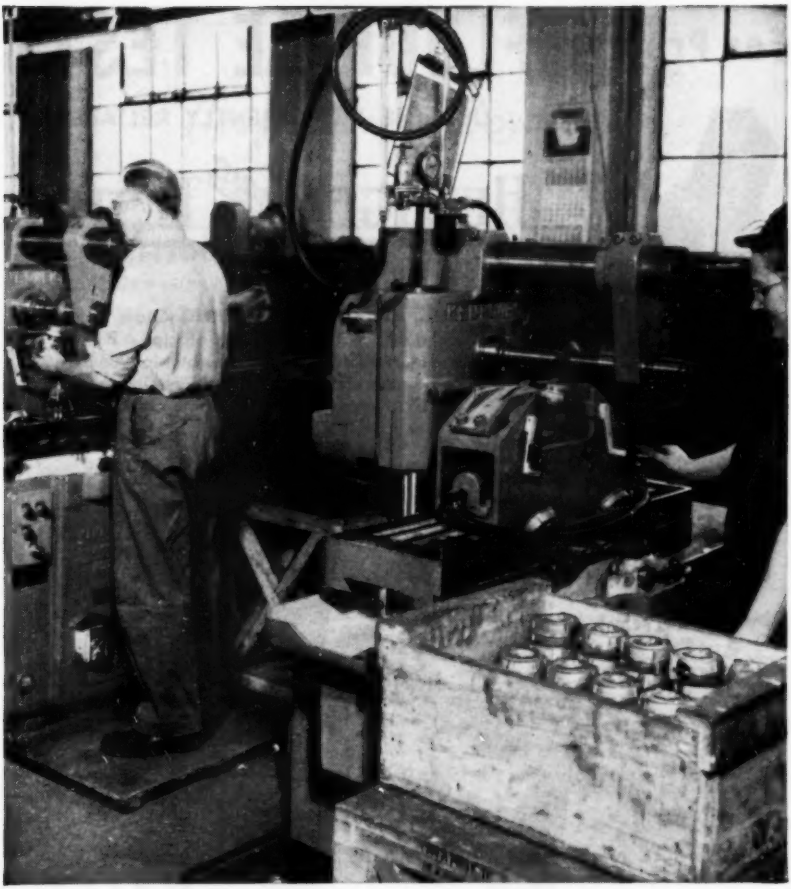
MOVING
?

Please advise A.W.W.A. promptly of any change in your mailing address. Leaving a forwarding address at your old post office is not enough, because postal regulations require periodicals to be returned to the sender if not claimed at the original destination. And, to help us identify you properly, please include your old as well as your new address when writing.

Prompt notification will keep your Journals and other communications coming to you without annoying delays and lapses.

American Water Works Assn., Inc.
521 Fifth Ave. New York 17, N.Y.



BADGER PRECISION MEANS
"MORE FOR YOUR METER-MONEY"

"MEASURING THE WATER OF THE WORLD"

First for Accuracy • Low-Cost Maintenance • Durability • Sensitivity

BADGER Water METERS

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Branch Offices: New York City • Philadelphia
Worcester, Mass. • Savannah, Ga. • Cincinnati • Chicago • Kansas City • Waco, Texas
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For Precise FLUORIDE TESTS

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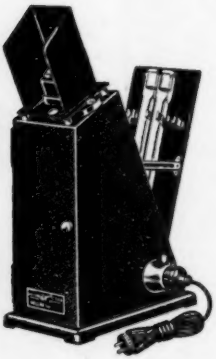

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NEW MEMBERS

Applications received September 1 to September 30, 1952

Abbott, Wayne H., Jr., Supt. of Water & Sewage, 400 Abbott Rd., East Lansing, Mich. (Jan. '52) *M*

Amaya-Valencia, German, Chief Engr., San. Eng. Service, Maracaibo Ministerio de Sanidad y Asistencia Social, Caracas, Venezuela (Oct. '52) *P*

Baldelli, Hugo, Sales Engr., Byron Jackson Co., Box 2017 Terminal Annex, Los Angeles 54, Calif. (Oct. '52) *R*

Benford, William Ramsden, Assoc. Prof. of Civ. Eng., Brown Univ., Providence 12, R. I. (Oct. '52) *P*

Beretta, J. W., Engrs., Inc., Malcolm A. Collins, 902 Travis Bldg., San Antonio 5, Tex. (Corp. M. Oct. '52)

Berryman, James C.; *see* Valley Cities Supply Co.

Bertrando, Bertrand R., Field Engr., Infilco Inc., 6404 Hollywood Blvd., Los Angeles, Calif. (Oct. '52) *RP*

Biederman, Walter J., Chemist, Water Works, 1000 Columbus Ave., Waco, Tex. (Oct. '52) *P*

Blytheville Water Co., C. W. Kapp, Mgr., Blytheville, Ark. (Corp. M. Oct. '52)

Bradley, Floyd Edison, Supt., Coline Gasoline Corp., 4549 Produce Plaza, Los Angeles 58, Calif. (Oct. '52) *RP*

Branch, J. H., Owner, Happy Valley Waterworks, 623 Happy Valley, Carlsbad, N.M. (Oct. '52) *MRP*

Brown, Curtis C., Supt. of Water Works, Kentland, Ind. (Oct. '52)

Bullen, C. K., Director of Physical Plant, Oklahoma A & M College, Stillwater, Okla. (Oct. '52) *M*

Butkiewicz, Joseph Wallace, Civ. Engr., Board of Water Supply, 120 Wall St., New York 5, N.Y. (Oct. '52) *P*

Champion, Clifford W., Mgr., Sea Breeze & Vicinity Water Dist., 4444 Culver Rd., Sea Breeze, N.Y. (Oct. '52) *MRP*

Clark, Ernest Roy, Supt., Water Dept., City Hall, Burlingame, Calif. (Oct. '52) *M*

Collins, Malcom A.; *see* Beretta, J. W., Engr., Inc.

Conway, Hollis Ross, Dist. San. Engr., Public Works Office, 8th Naval Dist., New Orleans 14, La. (July '52)

Coogan, Frank J., Director, Div. of Research, State Dept. of Wildlife & Fisheries, Box 9055 University Station, Baton Rouge 3, La. (Oct. '52) *R*

Craig, Allen, Cons. Engr., Wood & Craig, 511 Philtower Bldg., Tulsa, Okla. (Oct. '52)

Crispin, Charles Byron, Supt., Munic. Light & Power & Water Dept., Grimes, Iowa (Oct. '52) *MRP*

Dieterich, Bernd H., Student, Harvard Univ., 46 Perkins Hall, Cambridge, Mass. (Jr. M. Oct. '52) *P*

Doty, C. W., Supt., H. L. Pelton, 109 N. Montgomery St., Clarksville, Ark. (Oct. '52) *MRP*

Drye, Rohn F., Jr., Design Engr., K. W. LeFever, 304 Gazette Bldg., Little Rock, Ark. (Oct. '52) *RP*

Geneva, City of, Glen Johnson, Water Comr., Geneva, Neb. (Munic. Sv. Sub. Oct. '52)

Hague, William C., Chief Engr., Metropolitan Water Dist., 703 Tribune Bldg., Salt Lake City, Utah (Oct. '52)

Hall, Benjamin Mortimer, Jr., Hydr. Engr., Wiedeman & Singleton, Box 1878, Atlanta, Ga. (Oct. '52) *MR*

Heater, R. O., Pres., Heater Well Co., 306 S. Salisbury St., Raleigh, N.C. (Oct. '52) *R*

Hess, John Samuel, Supt. of Water & Sewage Treatment, 1233 Stilwell Ave., Fremont, Ohio (Oct. '52) *MP*

Hicks, Howard A., Supt., LaCanada Irrigation Dist., Box 37, LaCanada, Calif. (Oct. '52)

(*Continued on page 32*)

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(*Continued from page 30*)

Holly, Paul, Foreman of Maint. & Operation, Water Dept., 110 South St., Morristown, N.J. (Oct. '52) *MRP*

James, Worth, Contractor, Worth James Constr. Co., 1007 Pyramid Life Bldg., Little Rock, Ark. (Oct. '52) *MR*

Johnson, Glen; *see* Geneva (Neb.)

Kapp, C. W.; *see* Blytheville (Ark.) Water Co.

Keirn, Merwyn I., Sales Engr., Wallace & Tiernan Co., Inc., Route 2, Urbana, Ohio (Oct. '52) *P*

Kenning, Robert Stanley, Asst. Supt., Dept. of Public Works, Birmingham, Mich. (Oct. '52) *M*

Kent, Eugene L., Water Supply Operator, 109 Sherman Ave., Williston Park, N.Y. (Oct. '52) *M*

Laforet, Eugene A., Supt., Public Utilities Com., 112 Tecumseh Rd., W., Tecumseh, Ont. (Oct. '52) *M*

Leeke, Clyde C., Supt., Auburn, Ind. (Oct. '52)

Lidgerwood, William V., Chem. Sales, Aluminum Import Corp., 630—5th Ave., New York 20, N.Y. (Oct. '52) *P*

Majury, Samuel S., Dist. Mgr., Factory Mutual Eng. Div., 44 King St. W., Toronto, Ont. (Oct. '52) *MR*

Marsh, James Z., Owner-Mgr., Culligan Soft Water Sales & Service, Box 551, Redlands, Calif. (Oct. '52) *P*

McBride, Don, Mgr., Oklahoma Water Development Assn., Rm. 414 Kerr-McGee Bldg., Oklahoma City, Okla. (Oct. '52) *R*

McCrea, W. H.; *see* McCrea Corrosion Eng. Co.

McCrea Corrosion Eng. Co., W. H. McCrea, Pres., 506 N. Cedar St., Tipton, Iowa (Assoc. M. Oct. '52)

McGregor, John McKenzie, McGregor Eng. & Mfg. Co., Box 1141, Tulsa, Okla. (Oct. '52)

Miller, Paul C., Vice-Pres., The Herbert Chem. Co., Vine St. & Murry Rd., Cincinnati 17, Ohio (Oct. '52) *P*

Morse, Frank S., Engr., Water Dept., 275 N. 17th St., Salem, Ore. (Oct. '52)

Moulton, George L., Engr., V. P. Ewin Eng. Corp., 622 First National Bank, Montgomery, Ala. (July '52) *P*

Myers, Paul Clifford, Water Dept., City Hall, Pasadena, Calif. (Oct. '52) *M*

Napier, Garrett H., Water & Waste Engr., Ford Motor Co., 13025 S. Dixie Highway, La Salle, Mich. (July '52) *MP*

Northover, A. C., Mgr., Water & Sewerage Corp., Greater Corner Brook, N.F. (Oct. '52)

Pier, Laura (Miss), Secy.-Treas., Utility Supply Co., 5828 Havey Wilson Dr., Houston, Tex. (Oct. '52) *M*

Powell, Nixon Wesley, Asst. San. Engr., U.S. Public Health Service, 519 Federal Bldg., Little Rock, Ark. (Oct. '52) *RP*

Prock, Andrew, Salesman, Victory White Metal Co., 6100 Roland Ave., Cleveland 4, Ohio (Oct. '52) *M*

Quinlan, Richard T., Field Engr., Infilco Inc., Rm. 205, Euclid-71st Bldg., Cleveland, Ohio (Oct. '52) *P*

Roddick, Andrew W., Supt., King County Water Dist. No. 75, 19863—28th Ave. S., Seattle 88, Wash. (Oct. '52) *M*

Roser, Fred A., Sr. Engr., Board of Water Supply, Utica, N.Y. (Oct. '52)

Ruff, Wilson L., Supt., Elec. & Water Dept., Covington, Tenn. (Oct. '52)

Schneider, Robert W., San. & Industrial Hygiene Engr., 9th Medical Group, Travis Air Force Base, Calif. (Jr. M. Oct. '52) *P*

Simon, Carl H., Vice-Pres. & Chief Engr., Darling Valve & Mfg. Co., Williamsport, Pa. (Oct. '52) *M*

Straughan, George O., Resident Engr., Fell & Wheeler, 1754 Utica Sq., Tulsa, Okla. (Oct. '52) *M*

Suenram, Wayne C., Supt. of Utilities, Moundridge, Kan. (July '52) *MR*

Thompson, D. W., Supt., Water Plant, Water Dept., 505 S. Emporia St., El Dorado, Kan. (July '52) *MP*

Valley Cities Supply Co., James C. Berryman, Vice-Pres., 853 East Valley Blvd., San Gabriel, Calif. (Assoc. M. Oct. '52)

Watkins, George Reynolds, Partner, J. Stephen Watkins, 251 E. High St., Lexington, Ky. (Oct. '52) *P*

Williams, Robert LaFayette, Sales Engr., Wallace & Tiernan Co., Inc., 513 S. Tryon St., Charlotte, N.C. (Oct. '52) *P*

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Wilson, Harold William, Meter & Service Sec., Water Distr. Div., Dept. of Water & Power, 207 S. Broadway, Los Angeles, Calif. (Oct. '52) *M*

Wolf, Lawrence F., Water Works Operator, Ford Motor Co., 26228 Ypsilanti St., Flat Rock, Mich. (July '52) *MP*

REINSTATEMENTS

Ayers, Edward D., Service Engr., Rockwell Mfg. Co., 64 Susquehanna Ave., Cooperstown, N.Y. (Apr. '47)

Flynn, Martin W., Trustee, Water Works, 35 N. Main St., Council Bluffs, Iowa (Jan. '44)

Greenfield, Harry C., Prin. Engr., State Dept. of Health, Trenton, N.J. (Apr. '44) *MRP*

Maurer, George V., Supt. of Water, 46 Ocean Ave., Freeport, N.Y. (Jan. '43)

Shaw, Robert S., Chief, Bureau of Public Health Eng., State Dept. of Health, Trenton, N. J. (Jan. '43) *MRP*

LOSSES

Deaths

Billings, L. C., Supervisor & Chief Chemist, Water Treatment, Dallas 1, Tex. (May '23) *Fuller Award '52.*

Fairbairn, John M., Pres., Charles Warnock & Co., Ltd., 31 St. James St., W., Montreal, Que. (Apr. '34) *P*

Holder, H. C., Trustee, Water Works, 217 McGee Ave., Council Bluffs, Iowa (Jan. '46)

Paterson, A. B., Chairman of the Board New Orleans Public Service, Inc., 317 Baronne St., New Orleans 9, La. (July '37)

Romeiser, Charles H., Supt., Elec. & Water Dept., City Hall, Auburn, Ind. (July '43) *M*

Schneider, William, Chemist & Supt., Filtration Plant, Fremont, Ohio (Oct. '30) *P*

Thomas, Franklin, Prof. of Civ. Eng., California Inst. of Technology, Pasadena 4, Calif. (Mar. '30) *MR*

Resignations

Kapp, Clyde W., Mgr., Blytheville Water Co., 415 W. Main St., Blytheville, Ark. (Jan. '49) *MRPD*

Olsen, Harvey H., Relief Operator, Filtration Plant, R.F.D. 1, Pasco, Wash. (Apr. '52) *MP*

CHANGES IN ADDRESS

Changes received between September 5 and October 5, 1952

Adams, John, M., 1224—3rd Ave., W., Seattle 99, Wash. (Apr. '40) *MP*

Allen, James D.; *see* Yeatts & Allen

Arnold, Gerald E., Deputy Comr., Water Dept., City Hall Annex, Philadelphia 7, Pa. (Sept. '33) *Fuller Award '39. MRPD*

Banks, William G., Box 31, Colts Neck, N.J. (Dec. '19) *Fuller Award '39. Director '50-'53. MD*

Carder, E. G., Salesman, Hersey Mfg. Co., 1544 Monterey Pass Rd., Monterey Park, Calif. (July '46) *MRP*

Dore, Stanley Milburn, Apt. 14-A, 361 Clinton Ave., Brooklyn 5, N.Y. (Jan. '51) *R*

Drew, Samuel T., 1818 S. Bayshore Lane, Miami 45, Fla. (Jan. '50) *MRPD*

Driscoll, Dan, 501 E. Columbia St., Litchfield, Ill. (Apr. '47) *MP*

Duggan, Maury L., Mathieson Chem. Corp., Box 264, Jacksonville, Fla. (Oct. '51)

Dunham, F. E., Barber, Keels & Assoc., Inc., Box 1116, Columbia, S.C. (Apr. '30) *MRPD*

Ellerbusch, Robert P., Box 108, Ann Arbor, Mich. (Oct. '38)

Ferguson, Gerald W., American Embassy, APO 616, c/o Postmaster, New York, N.Y. (Jan. '42) *R*

Geren, John L.; *see* Salem (Ore.) Water Com.

Grantham, George R., USAFE Installations, Paris Office, APO 58, c/o Postmaster, New York, N.Y. (Jan. '44) *RP*

Gurney, Bert, Secy., Interstate Machinery & Supply Co., 1112½ Douglas St., Omaha, Neb. (July '35) *MP*

Henry, Thomas B., Jones, Henry & Williams, 821 Security Bldg., Toledo 4, Ohio (Jan. '39) *MRPD*

Hirsch, A. Alder, Water Purif. Supt., Dept. of Water & Sewerage, Box 65, Shreveport, La. (Apr. '41) *MR*

(Continued on page 36)

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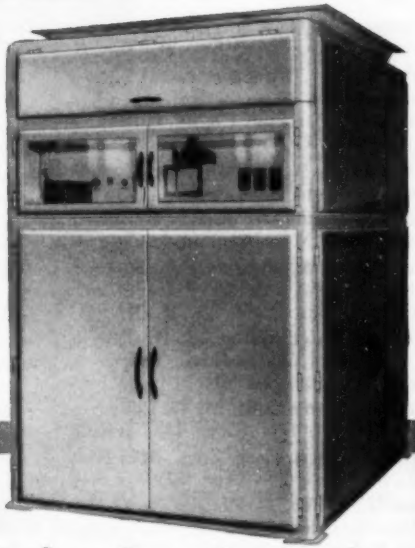

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(*Continued from page 34*)

Irwin, Thomas B., Asst. Western Sales Mgr., U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill. (Jan. '52) *MRPD*

Johns, J. G.; *see* Mathieson Chemical Corp.

Maihock, Donald J., 202 S. Albert St., Mount Prospect, Ill. (Jan. '50) *MRPD*

Mathieson Chemical Corp., J. G. Johns, Mathieson Bldg., Baltimore 3, Md. (Assoc. M. Mar. '20)

Nangle, B. A., Dist. Engr., Pennington County Health Unit, Rapid City, S.D. (Jan. '47) *P*

Nickerson, M. H., Engr., Factory Mutual Fire Insurance Co., Box 27, Matick, Mass. (Apr. '50)

Okun, Daniel A., Dept. of San. Eng., Univ. of North Carolina, Chapel Hill, N.C. (Jan. '49) *RP*

Owens, James B., 7415 Key Blvd., Arlington, Va. (Oct. '47)

Palevsky, Gerald, 61 Kalda Ave., New Hyde Park, N.Y. (Apr. '50) *PD*

Palm, Millard B., Office of the Air Surgeon, Headquarters 15th Air Force, March Air Force Base, Calif. (Jr. M. Oct. '51)

Parrsboro Water System, F. H. Tyrrell, Chairman of Water Com., Parrsboro, N.S. (Corp. M. Jan. '51)

Plummer, Raymond B., 132 N. Eddy St., South Bend, Ind. (Oct. '43) *MRPD*

Poirier, Cuthbert, Cons. Engr., 3175 Holt St., Montreal, Que. (Apr. '52)

Ponce G., Telmo, Maldonado No. 2.519, Quito, Ecuador (Jr. M. Jan. '52) *MR*

Ponte Valery, Antonio, Ave., El Parque, 319, Las Acacias, Caracas, Venezuela (Oct. '48)

Prostel, Edward, Research Engr., Natural Resources Research Inst., Univ. of Wyoming, Laramie, Wyo. (July '52) *MP*

Ramirez, Conrado S., 33 Samat St., Quezon City P.I. (Jan. '47)

Randall, Fred, Chief Operator, Bent Oak Filtration Plant, 904 Riverside Dr., Adrian, Mich. (July '49) *P*

Reynolds, Albert H., Consultant, 590 Hill Ave., Glen Ellyn, Ill. (Dec. '29) *P*

Rodgers, William A., 144 N.E. 97th St., Portland 16, Ore. (Jr. M. Oct. '51) *MRPD*

Rutherford, Kyle W., 7243 Remsen St., Apt. 5, Norfolk, Va. (Oct. '49) *M*

Salem, Water Com., John L. Geren, Mgr., Box 190, Salem, Ore. (Corp. M. Jan. '40)

Schneider, Robert, Dist. Geologist, U.S. Geological Survey, 226 Federal Bldg., Minneapolis 1, Minn. (Oct. '50) *R*

Solteldo Ramos, J. M., Civ. Engr., Ave. Octava, Quinta Araure, Altamire, Caracas, Venezuela (Jan. '49)

Southwest Water Co., Inc., 801 Calle Medina, Tucson, Ariz. (Corp. M. Jan. '52)

Sparling, Ray C., 225 N. Temple City Blvd., El Monte, Calif. (Oct. '39)

Stava, William, 2927 Regent St., Berkeley 5, Calif. (May '27)

Stone, Raymond V., Jr., 217 W. 1st St., Los Angeles 12, Calif. (Apr. '50)

Truman, Chester A., W. 3108 Providence St., Spokane, Wash. (Dec. '26) *Director '37-'40. Fuller Award '45.*

Tyrrel, F. H.; *see* Parrsboro (N.S.) Water System

Valentino, John G., Sr., Southern Sales Mgr., Badger Meter Mfg. Co., Box 398, Saint Simons Island, Ga. (Apr. '45) *P*

Ward, James W., 106 Taylor St., Silver Bluff Estates, Aiken, S.C. (Oct. '50) *MRPD*

Ware, Stanton J., Chief, Water Projects Sec., CDCA, U.S. Public Health Service, Box 386, Salt Lake City 10, Utah (July '48)

Webb, Lester C., Tech. Sales, Infilco Inc., Box 1360, Nashville, Tenn. (July '51) *MP*

Weight, Walter O., Dist. Mgr., Hersey Mfg. Co., 1544 Monterey Pass Rd., Monterey Park, Calif. (Jan. '42) *MRPD*

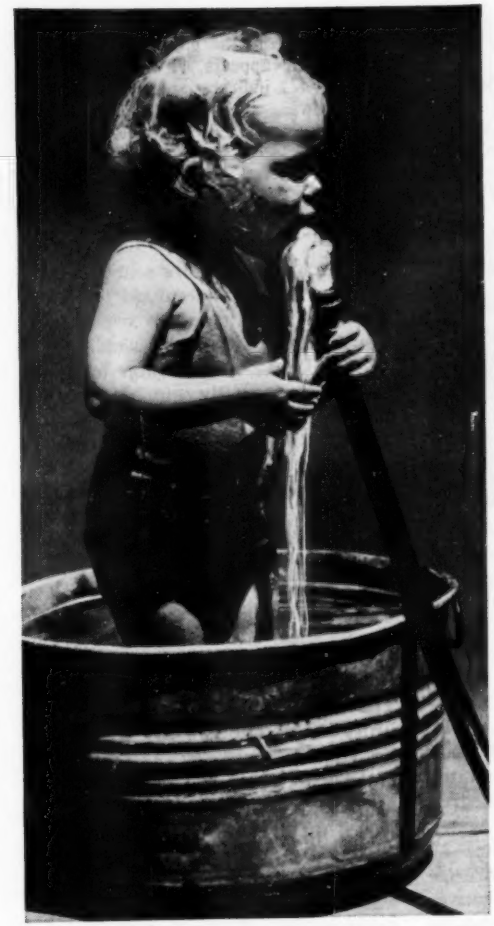
Wertz, Emerson D., 1039 N.E. 104th St., Miami 38, Fla. (Jan. '47) *MRP*

Wood, C. K.; *see* Worthington, Corp.

Worthington Corp., C. K. Wood, Vice-Pres., 401 Worthington Ave., Harrison, N.J. (Assoc. M. June '01)

Yeatts & Allen, James D. Allen, 158½ Cypress St., Abilene, Tex. (Corp. M. July '50)

Zimmerman, Harry F., 525 Telfair St., Augusta, Ga. (July '47) *RP*



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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.A.—Water Pollution Abstracts (Great Britain).*

QUALITY OF WATER

Recent Experiences of Biological Damage in the Water Systems of Factories. H. BEGER. Gesundh.-Ing. (Ger.), **69**:172 ('48). Difficulties caused by the development in water-supply systems of water snails, mussels, fresh-water sponges, Bryozoa, and fly larvae are discussed. Illustrated accts. are given of the organisms. Methods by which they enter the systems, conditions which encourage their development, and methods of preventing their entry and of removing accumulations are discussed.—*WPA*

Indexes of Quality of Water From Subterranean Sources. V. N. KONONOV. Gigiena i Sanit. (USSR), **1951**: 11:13 ('51). Generally the magnitude of specific oxidizability of the water specimen (i.e. oxidizability per degree of color) is a fair index of water quality for judging the presence of fresh org. matter of animal origin. Inorg. NH_4 is not very indicative. Specific oxidizability under 0.3 usually means safe drinking water from the sanitary point. In presence of ferrous salts the results are too high; the same is true of waters contg. much humic acid material. Chlorination of water with an index below 0.3 generally gives a stable bactericidal effect, which is not true of water with a higher oxidizability coeff.—*CA*

Sulfates in Drinking Water. N. L. PETERSON. Off. Bul. N.D. Wtr. & Sew. Wks. Conf., **18**:10:6, **18**:11:11 ('51). Anal. of more than 2000 replies to a questionnaire sent to people drinking highly mineralized waters in N.D. indicated that water contg. more than 750 ppm sulfates is usually laxative, and that water contg. less than 600 ppm is normally safe. Magnesium sulfate is more purgative than sodium sulfate. Persons who have recently started to use the water can tolerate lower concns. than those accustomed to it. The author considers that the max. level of 250 ppm sulfate recommended by the U.S. Public Health Service could be raised to 500 ppm without producing any undesirable physiological effects on those consuming the water.—*WPA*

The Occurrence of Pronounced Salinity Variations in Louisiana Coastal Waters. R. A. GEYER. J. Marine Research, **9**:100 ('50). To investigate pronounced variations observed in the salinity of Louisiana coastal waters to the west of the Mississippi delta, the content of chloride was determined in 700 samples of sea water by the std. titration method and results were converted to salinity values using the formula given by Sverdrup, Johnson, and Fleming. Samples were taken over a period of 14 mo., from a mean depth of 10 ft below the surface, and at distances of 6–8 miles from the shore. Results obtained by this method agreed closely with those obtained from observations on the temp. and density of sea water in this area. It was found that a close correlation exists between seasonal changes in salinity and variations in the discharge from the Mississippi R. Fre-

(Continued on page 40)

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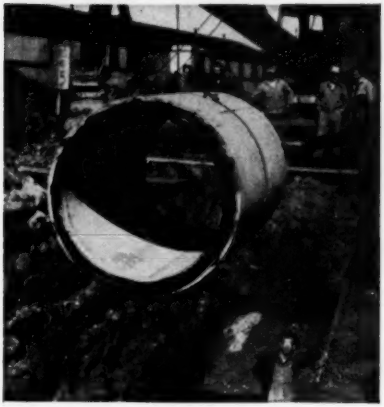

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(*Continued from page 38*)

quent short-term variations also occur and it is probable that local drainage patterns and the characteristics of ocean currents also affect salinity. The author points out that variations in salinity involve variations in other chemical and physical properties of sea water; therefore marine organisms must make constant physiological adjustments to changes in their environment.—*WPA*

Some Effects of Inorganic Salts on the Blood Specific Gravity and Tissue Fluids of the Bluegill, *Lepomis macrochirus Raf.* R. Abegg. Physiol. Zool., **23**:124 ('50). To explain some of the effects on fish of poln. by industrial waste waters, the author investigated the effect of some inorganic salts on the internal water balance of the bluegill, *Lepomis macrochirus*. He first determined the 24-hr median tolerance limit of the fish for each salt —that is, the concn. of the salt in which half the test animals could survive for a period of 24 hr. Fish were placed for 24 hr in test solns. of concns. at the 24-hr median tolerance limit, at a temp. of 22 ± 0.2 C. The effects of the following salts were tested: sodium sulfate, chloride, orthophosphate, chromate, dichromate, and carbonate, and calcium and potassium chloride. A falling drop densiometer was used for measuring changes in the specific gravity of the blood of the fish, and the content of moisture was determined in a strip of dorsal muscle removed from one side of the fish. As controls, fish, under the same conditions as those in the test soln., were placed in reference water—that is, water contg. all the major ions in concns. and proportions typical of an avg. surface water of the U.S. Solns. of sodium sulfate, chromate, and orthophosphate had no effect on the water balance of the fish exposed for 24 hr; all the fish survived, possibly because the fish used in these tests

(*Continued on page 42*)

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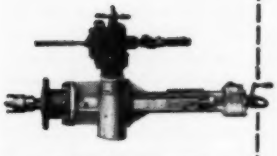

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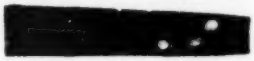

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(Continued from page 40)

were larger than those used in the tests for determining the 24-hr median tolerance limit. Solns. of potassium and calcium chloride caused the fish to lose tissue fluids although the specific gravity of their blood varied only slightly from that of the control fish. Fish in a solution of sodium carbonate for 7 hr showed a gain in tissue fluid of 1.24% over the controls, but no significant change in specific gravity of the blood was noted. The mean values for tissue fluid and specific gravity of the blood of fish in the sodium dichromate solution indicated a significant general hydration of the whole animal, whereas sodium chloride had a dehydrating effect. The exptl. results are given in tables.—*WPA*

ANNUAL REPORTS

Chicago (Ill.) Department of Public Works. Annual Report (1950). Ordinary water works revenue: assessed rates $4,166,844, meter rates $14,335,988, miscellaneous $650,557, total $19,153,388. Ordinary expense: operation $10,148,512, repairs and renewals $5,138,499, interest on certificates and judgments $1,128,117, total $16,415,128. Excess of revenue over expenses $2,738,260. Additions, extensions, and betterments $4,888,866. Assessed rates accounts 316,931, avg. bill $6.57; meter rates accounts 121,834, avg. bill $19.11. Free water $877,120. Visits for shutoffs to enforce collections 72,171. Avg. pumpage 951 mgd (max. 1235), of which 70 mgd to 48 communities and industries outside city. Per capita city consumption by 3,625,000 pop., 242.9 gal. Operating and maintenance cost of pumping water $12.55 per mil gal, 9.5¢ per million ft gal. Mains 3972 miles, hydrants 43,313, gate valves 40,930. Maintenance cost for mains, hydrants, valves, services, meters, and related items $710.89 per mile of pipe. Of 12 pumping stations, 3 supplied with filtered and chlorinated water, other 9 chlorinated water only. Plans being prepd. for filter plant to serve central and north sections. Avg. Cl dosage at 9 central and north district stations 9.32 lb per mil gal, avg. residual in water leaving stations 7.3 lb per mil gal, in distr. system samples 3.9. Avg. coliform index in representative samples from distr. system 0.122 per 100 ml, compared with 0.04 in south district; avg. for whole system 0.096. Automatic residual recorders at all stations but one. Helicopter employed for sampling for lake surveys. Water pumped by low-lift pumps and chem. treated at south district filter plant 308.6 mgd; plant operating cost $12.46 per mil gal low-lift pumpage, labor $5.59, chem. $3.75, elec. $1.18. Cost of carbon for taste and odor removal $1.47 per mil gal, 39% of total cost: completely effective. Equip. for applying carbon in slurry form installed. Avg. Cl dosage 14.5 lb per mil gal, alum 104.8, lime for corrosion control 20.9, C 25.5. Avg. residual Cl: leaving plant 5.3 lb per mil gal, pumping station 4.3, distr. system 3.4. Plant scale tests with $FeSO_4$ and high lime dosage and recarbonation indicated such treatment effective for settling plankton from clear lake water and prolonging filter runs. Avg. coliform index per 100 ml: plant outlet 0.008, pumping station 0.019, distr. system 0.04. Present and confirmed positive in filtered water 1.71 and 0.25% in 100 ml, resp., and 0.27 and 0.13% in 10 ml, resp. Avg. turbidity plant outlet water 0.00 ppm, compared with 6.3 for remainder of city. Final alky. 105 ppm, hardness 135, plankton 0.4 organisms per ml, pH 7.9, threshold odor 1. Avg. removal of plankton by coagulation and settling 92.5%. Avg. monthly filter run varied from 42.1 hr in Dec. to 18.7 in Feb.; annual avg. 29.9. Wash water 1.6%. Underground street leakage stopped in advance of street pavement 0.64 mgd in 18 miles of pipe, and under special

(Continued on page 44)

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(Continued from page 42)

rehabilitation work in connection with waste control 10 mgd in 114 miles of pipe: cost of latter work $516,944. Since '31, leakage of 319 mgd from 4045 miles of pipe located and stopped. House-to-house leakage and waste survey continued; 29,915 premises inspected and 45,067 leaks found; also 2949 public bldgs. and 6215 leaks found. Based on meters in service (121,834), avg. cost of maintenance $3.97 per meter. Reserve coal storage sufficient for 5–6 weeks' operation of all stations established; 19,887 tons placed in 2 piles, 8 and 12' high, resp., in layers not over 12" thick and thoroughly compacted to eliminate air which might start combustion. Mechanically agitated carbon slurry tanks (2) installed and on basis of experience acquired, 6 addnl. storage tanks and 2 feeder tanks planned. Bulk carbon in carload lots 4.3% cheaper than in bags; difference should pay for equip. in few years. Purchase and feeding of alum in soln. considered. Confirmation of positive presence of coliform tubes by examn. under electron microscope showed agreement with Standard Methods tests in 84% of 5000 specimens. Continued operation of 10 filters at 4–5 gal/sq ft/min showed that water of high quality obtainable at such rates even during winter. When conditions unfavorable for good coagulation, small amt. acid-treated Na silicate used. Examn. of sections removed for new connections indicate that, after 50 or more years service, c-i mains in good condition. Ten periods totaling 36 days when "oil refinery waste" type odors in raw water, max. hot threshold no. 70. Breakpoint prechlorination reduced carbon required for algal odors during summer. On one day, anchor ice formation

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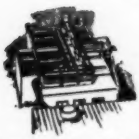

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(Continued from page 44)

in intake crib necessitated frequent detonations of dynamite and use of shore intake to furnish ⅓ of raw water. Kathabar dehumidifying units ($LiCl_3$) stopped condensation on pipe and walls of filter galleries, reducing corrosion of piping and equip. Surface-wash laterals (c-i) corroding because of poor original pipe coating, probably accelerated by addn. of carbon. Tests of protective coatings underway and cathodic protection equip. installed in one filter. Consumer water quality complaints 375, 56 only from portion of system served with filtered water; 65% because of turbid water, of which only 5% from south side. No deaths among 18 typhoid fever and 42 amebic dysentery cases; second successive year without typhoid fever death. Water intake crib employees examd. for detection of carriers. Medicinal taste in water dispensed from soda fountains due to phenolic plastic in water control valve on particular type of equip. —*R. E. Thompson*

Detroit (Mich.) Department of Water Supply. Annual Report (Year ended June 30, 1951). Revenue from water sales increased $955,221, due mainly to 5.66% increase in pumpage. Operating expenses increased $391,198, more than half because of wage increases. Assets $190,110,813, property, plant and equip. $151,996,372, bonds payable $58,443,000, reserves $56,168,380 (including sinking fund $26,314,020, and depn. $29,601,900), city equity $73,311,132. Operating revenue $14,275,655, operating expense $8,525,893, operating income $5,749,762, sinking fund earnings $666,720, miscellaneous income $200,697, interest $2,233,192, net income $4,383,987. Revenue from sale of water $13,928,010, of which 88.86% consumption revenue, 11.14% service charge. Revenue producing pumpage 86.78%, nonrevenue pumpage 13.22%. Avg. revenue per 1000 cu ft revenue-producing pumpage 83.5¢ per 1000 cu ft, total pumpage 72.5¢ Delinquent balance, Detroit accounts, $65,692, final cut-off notices served 28,507. Services 383,435, meters 378,253, gate valves 30,440, hydrants 30,180, mains 5385 miles. Avg. cost of testing 49,107 meters varied from 14.8¢ for ⅝″ to $14.12 for 8″. Avg. cost of installing meters $16.91 for ⅝″, $22.46 for ¾″, and $37.59 for 1″. Avg. cost of repairing ⅝″ meters damaged by frost, hot water, and wear and tear $3.94, $4.44, and $4.11, resp. Consumption 154 gpcd. Pop. supplied, city 1,886,000, suburban 718,000. Avg. pumpage 394 mgd (max. 595), approx. equal amts. from each of Waterworks Park and Springwells plants. Coliforms (MPN) in raw water increased to 820 compared with all-time high of 364 previous year—3 individual sample indices 110,000. At Waterworks Park, turbidity 2–140 ppm, avg. 20. Alum dosage 3.1–26.1 ppm, avg. 11.6, 0.6 ppm per ppm turbidity removed. Total Cl dosage 0.87–1.8 ppm, avg. 1.16, of which 1.0 ppm prechlorination. Coliforms absent in all 21,900 tap samples; all 4857 distr. system samples met USPHS standard. Hourly samples of raw water treated with Cl. 1.3% developed chem. medicinal tastes on incomplete chlorination. Hourly effluent samples all negative. At Springwells plant, avg. alum dosage 10.9 ppm. Most of prechlorination dosage applied at Waterworks Park. Longer contact in raw water tunnel necessitated higher total prechlorination dose (1.09 ppm). Here also all 21,900 tap samples negative for coliforms and effluent free from taste. Complaints investigated 679, sickness 3, unjustified; taste and odor 77, all due to local conditions; turbidity 599, of which 396 due to hydrant operation. Avg. and max. turbidity of applied water at Waterworks Park and Springwells 25 and 10

(Continued on page 50)

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PITMAN HYDRA-LIFT
versatile inexpensive truck crane
Especially developed for handling pipe, the new Pitman Hydra-Lift uses hydraulic power to swing boom 180 degrees, lift boom 100 degrees. Boom telescopes from 12 to 22 feet. Lifting capacity is 6,400 pounds; requires only 40 inches behind the truck cab, leaving bed free for normal truck purposes. Moves from job to job at normal truck speeds. Hydra-Lift comes ready to install on the frame of any truck; two-ton truck or larger recommended. Write today for complete information on the new Pitman Hydra-Lift!
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This pipe saves tax dollars

Generations of taxpayers have been saved millions in taxes by the long life of cast iron pipe in America's water distribution systems. For example, more than 35 cities have cast iron mains in service that were installed over a century ago.

Yes, cast iron pipe has saved, and is today saving, millions in tax dollars—but that is not all. Street excavations to replace short-lived pipe cost money in disruption to traffic and retail trade, not to mention the expense of installing new pipe and repairing costly pavement. Cast iron pipe saves these avoidable costs. And the dependable service of cast iron mains in high-pressure fire-fighting systems has saved millions in fire losses. Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 South Michigan Ave., Chicago 3, Illinois.

This cast iron water main installed in Alexandria, Virginia, 100 years ago is still rendering satisfactory service. Over 35 other American cities have century-old cast iron mains in service.

CAST IRON ®

CAST IRON PIPE

America's No. 1 Tax Saver

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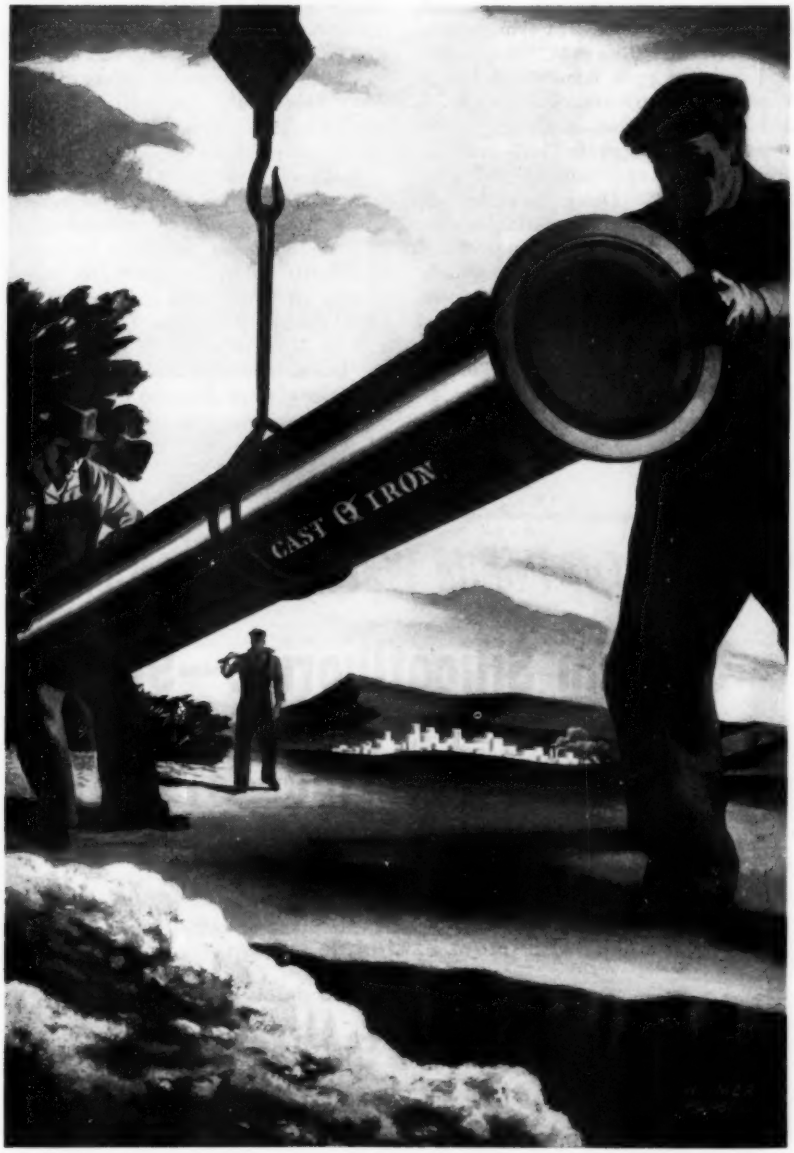
—but that is not all



(*Continued from page 46*)

ppm and 25 and 8, resp. Waterworks Park avg. wash water, filtration rate, and filter run 2.6%, 166 mgd, and 31 hr, resp.; at Springwells, 6.5%, 179 mgd, and 28 hr, resp. Avg. 37 C count of effluent of both plants 0. Max. and avg. effluent residual Cl at Waterworks Park 0.47 and 0.46 ppm, Springwells 0.51 and 0.48 ppm, resp. Avg. pH at Waterworks Park and Springwells 7.6 and 7.5, resp. Max. and avg. carbon applied at Springwells 1.01 and 0.9 ppm, resp. Avg. hardness 100 ppm, total solids 128. Detention periods in coagulation and sedimentation basins, Waterworks Park and Springwells, 2 and 3 hr, resp.; number of filters (gravity) 80 and 68, resp.; rated capac. 320 and 272 mgd, resp. Total filtered water storage 125 mil gal. Rates per thousand cu ft 62–92¢ plus monthly service charge of 24¢ for ⅝" meter, up. Min. bill $1.64 per quarter. Gross operating revenue $5.60 per capita, $99.28 per mil gal. Purif. cost per mil gal $5.49.—*R. E. Thompson*

Halifax (N.S.) Public Service Commission. Annual Report (1951). Pop. 103,119 per mile of water mains. 883 miles of water mains. Pptn. 54.4", 83-yr avg. 55.4". Impounding reservoirs (4) 992 acres, total watershed 10,155 acres. Mains, lakes to city 10.4 miles; inside city 117 miles; total storage 2473 mil gal. Service reservoir capac. 3.64 mil gal. Gross value of plant $8,357,971, provision for depn. $2,057,216, net value $6,300,756. Operating revenue $864,164, operating expenses $447,878, depn. $75,000, debt service $239,607, paid to city in lieu of taxes $100,000, surplus $3883. Transfer of phys. assets to Public Serv-

(*Continued on page 52*)

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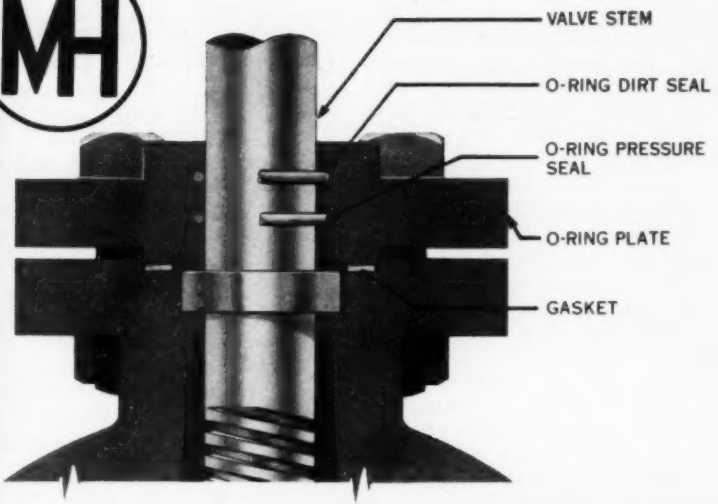

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M & H Gate Valves can be furnished if desired with rubber O-Ring Seals at top of the stem, as illustrated. This type seal replaces the conventional packing, stuffing box, and gland-follower design. The Seal Plate contains two O-Rings, one of which is the pressure seal while the other acts as a dirt seal.

The O-Ring Seal is tight and leakproof and requires little or no maintenance. Both the rings are made of a specially compounded rubber plastic which does not deteriorate. However, if it should become necessary, replacement of the O-Rings is a simple and easy operation. For complete information, write or wire M & H VALVE AND FITTINGS COMPANY, Anniston, Alabama.

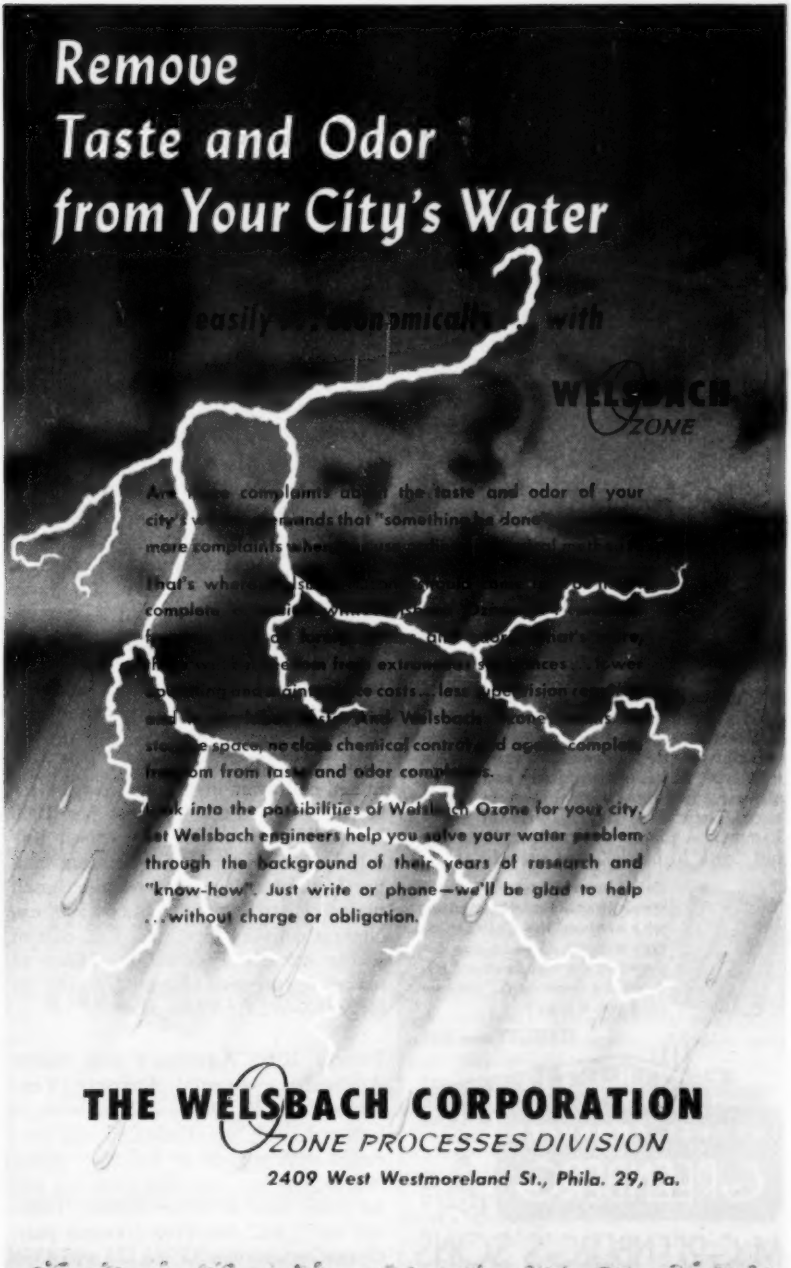
M&H PRODUCTS FOR WATER WORKS • FILTER PLANTS INDUSTRY • SEWAGE DISPOSAL AND FIRE PROTECTION

(*Continued from page 50*)

ice Com. arranged. Purchase of properties on watershed continued, $269,870 expended for this purpose; as houses and other bldgs. removed, contamn. continually decreasing. Customers 14,508; 300 bills issued daily on cyclic billing plan. Uncollectible accounts $650, less than 0.1% of water revenue. All personnel located in one new bldg., increasing efficiency. Lime treatment for correction of corrosivity commenced at Chain Lake (low service system); avg. pH increased from 4.8 to 6.5 by addn. of 5 ppm lime; corrosive action on metals reduced. At Spruce Hill Lake, avg. lime dosage 5.82 ppm; pH increased to 7.2. Avg. Cl dosage 1.28 ppm, providing 0.15–0.2 ppm residual after 22-min contact. Transmission main, 6700′ 20″ and 10,200′ 15″, cleaned by introducing scraper at 2 points; cost 2¢ per ft, carrying capac. increased 0.1 mgd. Despite increasing number of consumers, prompt detection and repair of leakage resulted in new 7-yr low consumption of 9.66 mgd. Meters tested at 5-yr intervals. Hydrants 844, valves 1726, meters 14,508.—*R. E. Thompson*

Johannesburg (S.A.) Rand Water Board. Annual Report (Year ended Mar. 31, 1951). Consumption 92.48 mgd (max. 120), of which 30.81 sold to Johannesburg and 20.75 to other 10 constituent municipalities, remainder to mines, etc. Rates: uniform rate to all consumers 7*d*. per 1000 gal, plus 6.5*d*. to consumers other than Railway Administration, member authorities, and crushing mines, less 3*d*. rebate to nonconstituent local authorities. Working costs 4.04*d*. per 1000 gal, provision for betterment, reserve, depn., and renewal funds 2.32 *d*., surplus transferred to fixed charges 0.64*d*., total 7*d*. (uniform rate). After addn. of fixed charges, total cost to member municipalities, railway and mines 9.44*d*., nonmember local authorities 10.5*d*., others 13.5*d*. Avg. cost to all consumers 9.6*d*., reduced from 59.45 in '05. Revenue £1,019,095, of which £984,551 from uniform rate. Loans outstanding £6,585,425, less redemption fund £2,421,017. Capital expenditures to date £14,294,780. Schemes in progress to increase available supply to 150 mgd. Principal source of supply Vaal R., which at Vereeniging is 35 miles south of Johannesburg and 1000′ lower in level. Vaal Reservoir, catchment area 18,000 sq miles, created by water board's Barrage 23 miles below Vereeniging. To augment rights to water in Barrage area, board purchased rights to abstract portion of water discharged and certain storage rights in government's Vaaldam, 50 miles upstream. Water pumped (120′ normal head) from 2 intake stations 1 and 3 miles, resp., from main station where primary mixing and sedimentation tanks, secondary mixing, carbonation and sedimentation tanks (total mean retention 17 hr), 102 rapid sand filters (avg. rate of filtration 62 gal/sq ft/hr), chlorination equip. and covered clear water reservoirs, from which water pumped 27 miles (head 575′) to Zwartkopjes pumping station, which repumps (head 1150′) to service reservoirs (total capac. 114 mil gal) on Central and East Rand, are located. Wells at Zuurbekom (chlorinated 0.09 ppm), 17 miles southwest of Johannesburg, augment Vaal R. supply on West Rand. Area of supply 4300 sq miles, pop. 2,354,000. Area of local authorities 733 sq miles, pop. 1,877,000, almost entirely supplied by water board, with exception of Pretoria, pop. 242,000. Rainfall at Johannesburg 30.33″. Total abstraction rights 225 mgd, of which rights to 29.375 mgd disposed of to industrial users near Vereeniging. Capac. of pumping and purif. plants and pipelines 100 mgd. Avg. quantity raised 99.57 mgd, 93.85% from Vaal R., remainder from wells.

(*Continued on page 54*)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(Continued from page 52)

Potable water produced 95.33 mgd. Elec. cond. of water entering purif. plant 110–725 micromhos per ml at 20 C, corresponding to 70–640 ppm electrolyte. Suspended solids 15–1416 ppm. Hydrated lime (65% CaO) used for primary coagulation 61.6–167.8 ppm, avg. 121.7 ppm; purified flue gas of 10% avg. CO_2 content for recarbonation, 6700–67,000 cu ft per mil gal (pH 8.7–9.1); alum for secondary coagulation after recarbonation 3.1–10.2 ppm, avg. 4.5 ppm; Cl 0.36–1.22 ppm, avg. 0.59 ppm. $CuSO_4$ applied as algicide in secondary stage as required, avg. 0.38 ppm. Total chem. cost 0.5*d*. per 1000 gal. Final hardness 45–250 ppm. Molluscs (*Lymnaea natalensis*) appeared in one secondary conditioning tank in Sept. and in clear water tower in Mar., but killed by $CuSO_4$. Bacterial count, 37 C, 48 hr: raw water 18–2090 per ml, purified water 5. Coliforms: raw water, present in from 0.1 to 10 ml, purified, absent in 50 ml in all 254 samples examd. Of 253–494 samples collected annually at village depot for independent examn. during past 10 yr, not one sample has contained coliforms in 100 ml. Avg. filter run 126 hr. Pumping cost per 1000 gal 1.5894*d*. per 1000 gal, raised 100′ 0.1035*d*. New pumping station and purif. plant (40 mgd) at Zuikerbosch under constr., est. cost £1,664,500, excluding delivery pipeline. Est. cost of whole scheme £5,011,800. Miles of mains in present system 476 (6″ or larger).—*R. E. Thompson*

Puerto Rico Aqueduct and Sewer Authority. Annual Report (Year ended June 30, 1951). Deficit brought forward since '46 eliminated and year ended with surplus of $63,686. Since '48, income has exceeded expenses and surpluses used to reduce deficit. Rainfall 64.7″, 6.6″ less than previous year. Operating income $3,983,173 ($3,436,487 from sale of water), miscellaneous

(Continued on page 56)

IN HAMILTON, ONTARIO—The problem was to install seven miles of 48″ line, fast, to meet the terrific demands of the city's rapidly expanding industrial and residential areas. A $1,900,000 job, including the filtration plant. With confidence, Hamilton engineers specified a Dresser-Coupled steel line.

A DRESSER-COUPLED STEEL LINE delivers water cheaper

The cheapest way to pipe water to where it turns into revenue is with a Dresser-Coupled steel line—the line that cuts *installation* costs, *leakage* losses and *maintenance* expense.

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Dresser Manufacturing Division, 59 Fisher Ave., Bradford, Pa. (One of the Dresser Industries). Warehouses: 1121 Rothwell St., Houston, Texas; 101 S. Bayshore Highway, South San Francisco, California. Sales Offices: New York, Philadelphia, Chicago, Houston, South San Francisco. In Canada: 629 Adelaide St., W., Toronto, Ont.

Be Sure you get the best line at the best price. Put steel pipe and Dresser Couplings in your specifications.

As in the case of this Hamilton line, existing pipe networks often seriously complicate the installation of new mains. Lighter, easier-handled steel pipe joined with Dresser Couplings—simpler to make up, even in cramped ditches—provides the swiftest, most practical way of getting under or around underground obstacles. The line is completed quicker—starts paying its way sooner.

Leakage losses are eliminated. *Controlled gasket pressure*, provided by the bolting up process in a Dresser Coupling, is your assurance of the correct *sealing* pressure all around the joint. Resilient Dresser gaskets absorb stresses from vibration, contraction and expansion, yet keep the joint "flexible-tight".

Maintenance is cut to the bone, too. Dresser Couplings last for life, and the absence of heat in joining prevents damage to glass-smooth pipe linings. High carrying capacity is sustained.

Experience all over the world proves that a Dresser-Coupled steel line gives you the ultimate in performance and economy. See your Dresser Sales Engineer or write our Bradford Office for detailed information.

(*Continued from page 54*)

$116,512, operation and maintenance $2,084,308, operating surplus $2,015,377, distributed as follows: debt and interest $1,305,015, depn. fund $494,643, expansion and improvement fund $209,794, miscellaneous $5925. Utility plant value $51,643,766. Customers 130,086. Constr. of filter plants at several municipalities underway. Services 95.6% metered. Appropriation of $4,500,000 necessary for rural aqueducts which are beyond resources of authority. Legislature contributed $300,000 this year, which, with unexpended balance from last year, made $580,344 available of which $326,760 expended during year to complete 16 rural aqueducts. Legislature appropriated $462,000 for water service to municipal offices and public fountains and $1,473,000 for new works. Water waste and pitometer surveys made throughout island. There are 15 filter plants, most quite small, in various municipalities. Prepn. made for constr. of 22 filter plants, 6 plants started, 1 finished. Filtered water met USPHS standard. Deep wells (72) produced 2203 mil gal. Río Grande de Loíza Project, placed in operation during year, comprises Loíza dam, 2500-kva hydroelectric plant, 40-mgd pumping plant, 5.5 km 48″ pipeline, and Loíza filter plant. Capac. of latter 30 mgd, provision for expansion to 60 mgd. Treatment includes aeration, chem. conditioning and sedimentation, filtration, and sterilization. Supplies metropolitan district, which includes San Juan, 11 other municipalities and rural zones, total pop. 545,000. Total water supplied by authority 56.37 mgd, of which 43.32 filtered, 7.01 partially treated, 6.04 from deep wells. Chemicals used: alum, lime, Cl.—*R. E. Thompson*

Sheffield (England) Corporation Waterworks Undertaking. Report and Abstracts of Accounts (Year ended Mar. 31, 1951). Capital expenditures during year £65,751, net capital expenditures to Mar. 31, '51, £7,958,787. Total income £825,068, of which £767,954 for water supplied at specific charges, working expenses £453,069, gross profit £371,999, interest and debt repayment (less interest on investments, etc.) £281,419, taxes £33,333, surplus £57,247. Of latter, £4,625 added to reserve fund, which on Mar. 31, '51, totalled £125,133. Capital indebtedness £4,271,279, debt repaid to date £3,456,118. Capital works completed included Hadfield covered concrete reservoir, Redmires filter station, and 13,952 yd new mains. Rainfall at Redmires 42.93″, long period avg. 40.5″. Available storage 6763 mil gal (13 impounding reservoirs), equiv. to 166 days' supply. Estd. pop. supplied in 136 sq miles, statutory direct area of supply 547,249; bulk supplies to addnl. 210,134 in neighboring areas. Water supplied in statutory area 25.09 mgd, 45.8 gpcd; total supplied 48.22 mgd, including 16.12 mgd compensation water. Cost of operating 5 filter plants 0.399-0.717*d.* per 1000 gal, avg. 0.58*d.* Of 791 tap samples examd., 99.4% free from coliforms and 99.6% free from *Esch. coli.* Small amts. alum produce perfectly clear and colorless water at Redmires plant, but Mn not removed at low pH necessary for coagulation and subsequently ppts. at higher pH in mains and services. Prechlorination not effective remedy. Omitting coagulation and applying both lime and Cl prior to filtration resulted in medicinal taste before effectiveness in removing Mn could be detd. Taste probably due to org. matter in filters. Meters 5713, hydrants 11,032, mains 969 miles.—*R. E. Thompson*

CORROSION AND CORROSION CONTROL

Role of Dissolved Oxygen During the Inhibition of the Corrosion of Iron by Sodium Phosphate Solu-

(*Continued on page 58*)

PLODDING ALONG WITH YOUR WATER SOFTENING SYSTEM?

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Check service efficiency. AMBERLITE IR-120 gives years of trouble-free service without attrition losses—is stable to waters of low silica content, oxidizing and reducing agents—can be operated safely over the entire pH range and at elevated temperatures. A typical AMBERLITE IR-120 unit has delivered almost 5,000,000 gallons of softened water per cubic foot of resin *without measurable capacity or attrition losses.*

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(Continued from page 56)

tions. M. J. PRYOR & M. COHEN. Nature (Br.), **167**:157 ('51). Preliminary results are given of an investigation to det. the effect of dissolved oxygen on the rate of corrosion of iron immersed in solutions of sodium phosphate at various pH values. The content of phosphate in the solutions was constant throughout the experiments. Under aerobic conditions corrosion ceased at pH values above 7.25 but under anaerobic conditions sodium phosphate had no inhibitory effect on corrosion at any pH value between 4.5 and 9.1.—*WPA*

Formation of Protective Coatings on Lead by Very Soft Waters. V. MULLER. Vom Wasser (Ger.), **18**: 226 ('50-'51). Studies on the effect of soft waters on dissolving lead pipes and the subsequent formation of protective coatings. The lead is not only dissolved but ppts. as a hard, dense, free of pores metal, so that the effect of oxygen corrosion is prevented. Addn. of potassium bicarbonate gives only partial protection, but small quantity of silicate (or combination of these two) is good. Addn. of chlorides and sulfates did not reduce the protection of the silicate. The protective coatings in naturally soft waters are probably the result of the effect of silicic acid and bicarbonates (carbonates) present. The same water, completely deaerated and neutralized, materially corrodes iron pipes. —*W. Rudolfs*

Lime Treatment and the Halifax Water Supply. G. LYALL RENNER. Eng. Cont. Rec. (Can.), **65**:5:112 (May '52). Supply, which contains

(Continued on page 62)

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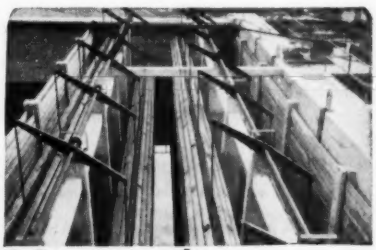

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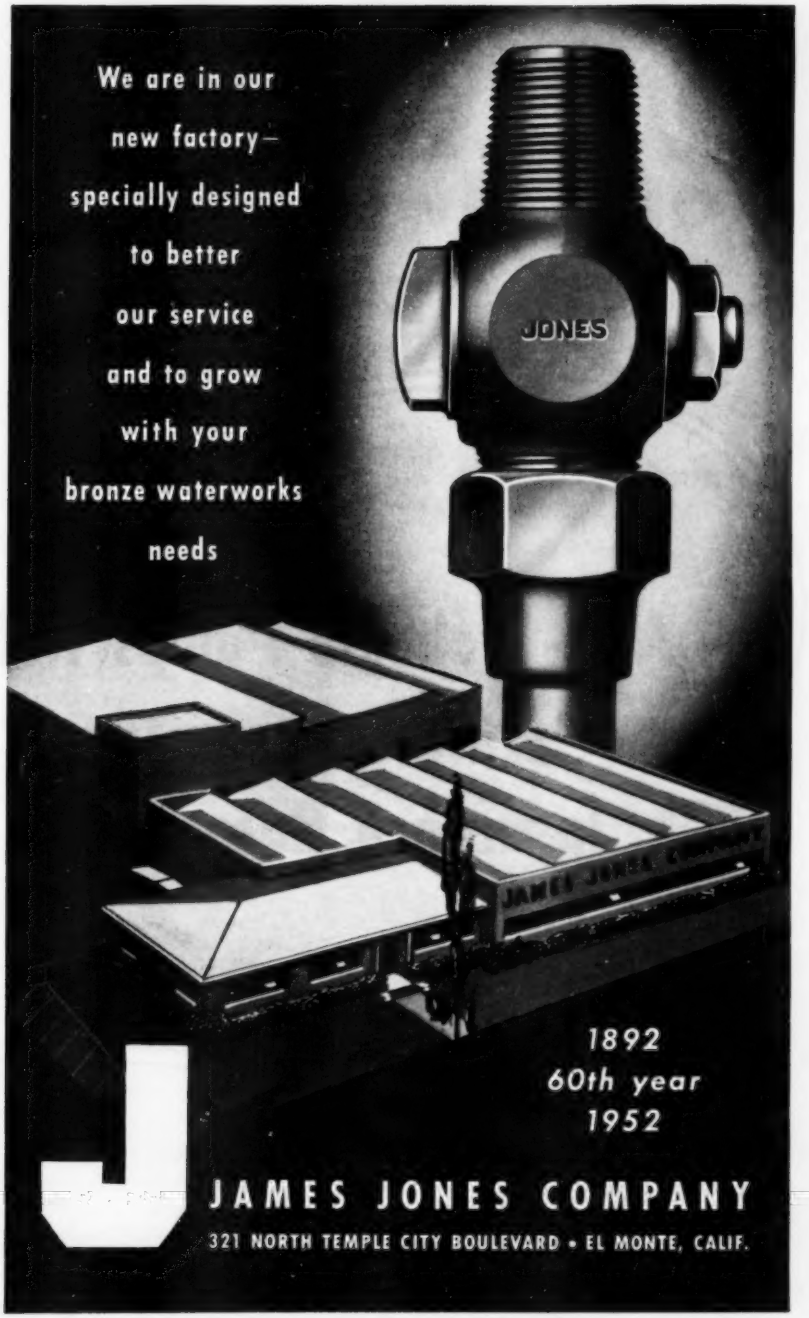
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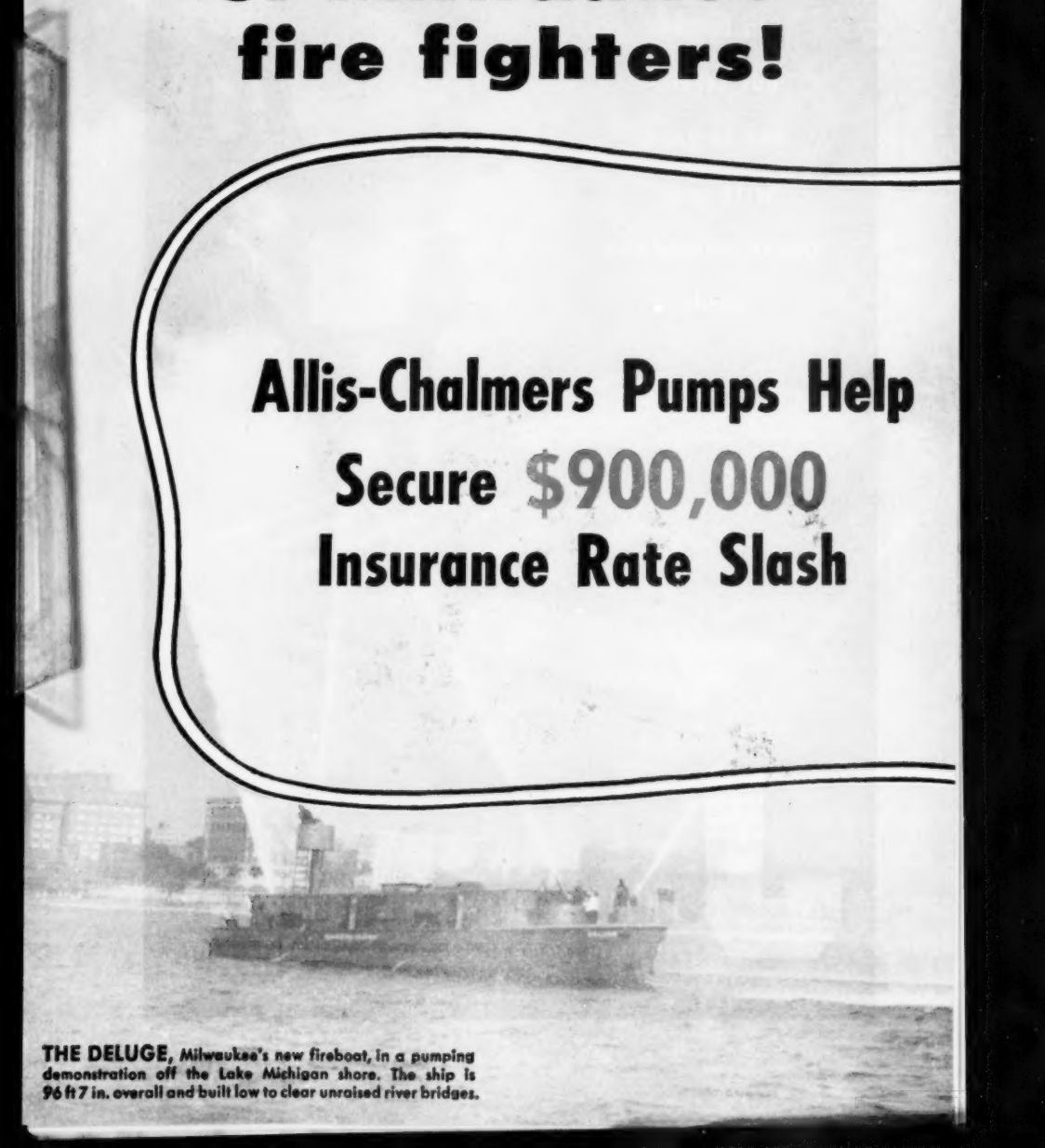
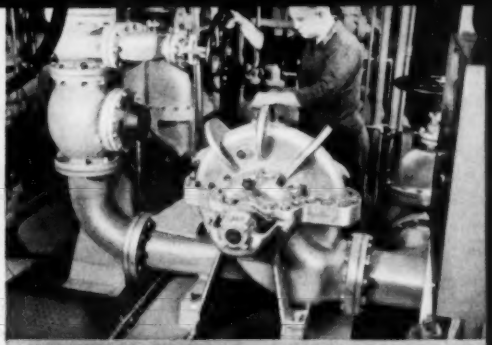


THE DELUGE, Milwaukee's new fireboat, in a pumping demonstration off the Lake Michigan shore. The ship is 96 ft 7 in. overall and built low to clear unraised river bridges.

BELOW DECKS, four Allis-Chalmers pumps supply the 4 water-throwing monitors and 14 three-inch discharge ports. Single stage construction reduces space and simplifies maintenance. Four Nordberg 375-hp, 600-rpm supercharged diesel engines supply power for propulsion and pumping.



MAIN PUMPS are each rated 3000 gpm at 150 psi, but have exceeded this by 11%. They are Type S, 10 by 8-in., bronze fitted, double suction centrifugal pumps. In 1951 the *Deluge* responded to 49 alarms, spent 72 hr and 23 min on duty at alarms, and pumped 1,145,125 gallons of river water.

A $900,000 ANNUAL PREMIUM SAVING results from the recent reduction in Milwaukee fire insurance rates. One of the very few cities so benefited, Milwaukee can be proud of the trained personnel and complete equipment in its excellent fire department.

Over 90% of the city's municipal pumps are Allis-Chalmers. And A-C pumps are used exclusively on the new fireboat *Deluge* — an important factor in Milwaukee's Class I Fire Department rating and Class II Fire Insurance rating. No city ranks higher, and few as high, in these ratings by the National Board of Fire Underwriters.

The *Deluge* — with a rated capacity of 12,000 gpm and proven capability of 13,835 gpm — is the largest capacity fireboat west of New York City. A fresh water dreadnaught with reinforced welded steel hull, it doubles as an icebreaker in keeping the Milwaukee, Menomonee, Kinnickinnic rivers and Burnham canal navigable. And, in addition to fighting fires, its pumps have proven valuable in aiding snow disposal in the rivers.

The *Deluge's* first "work call" was to fight from its decks a waterfront fire in a waste paper warehouse. More often it works as a floating booster station, pumping river water into a dry pipeline network in the commercial area. This separate system is put into action at conflagrations to supplement the city water supply.

When *your city* plans expansion or modernization, do as Milwaukee and other leading cities are doing — take advantage of Allis-Chalmers experience in municipal pumping equipment. For detailed information contact your nearest Allis-Chalmers district office or write to Allis-Chalmers, Milwaukee 1, Wis.

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A-C ALLIS-CHALMERS

(*Continued from page 58*)

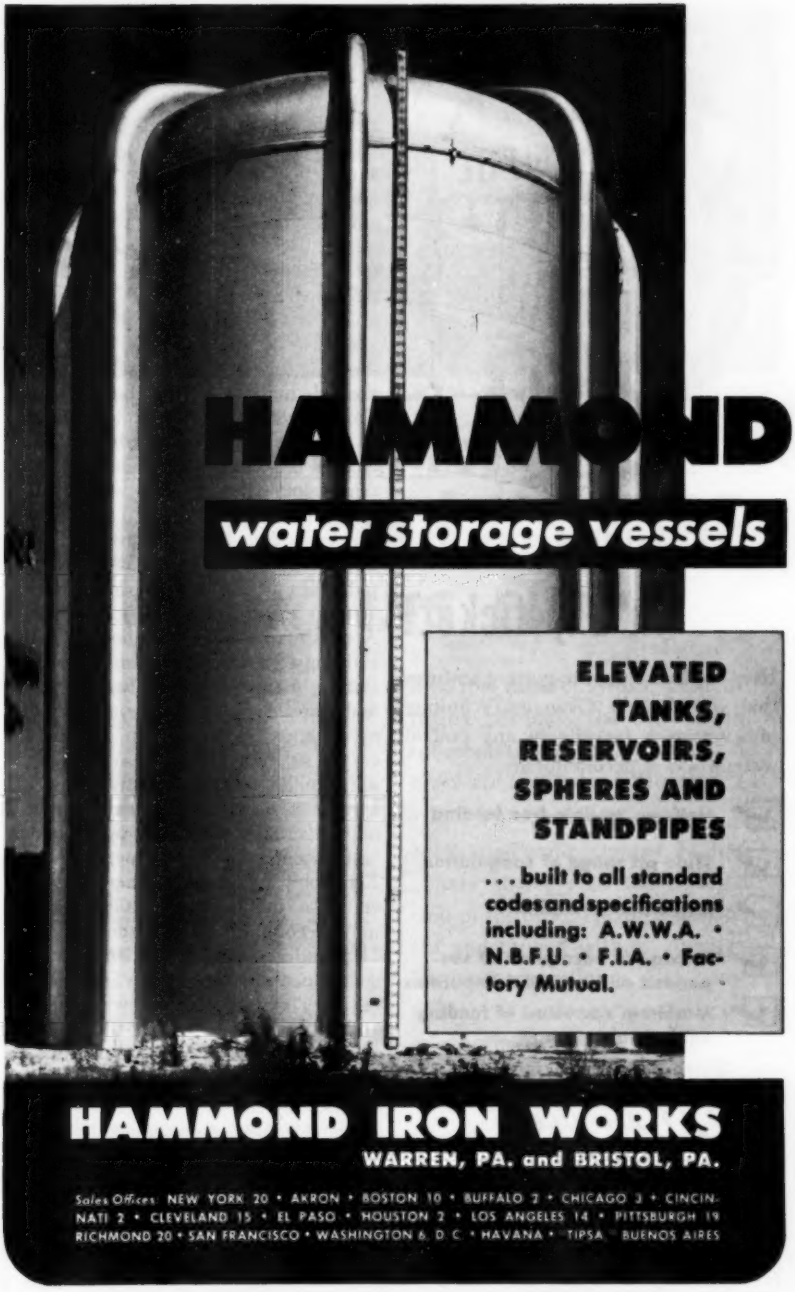
approx. 30 ppm total solids and 5 ppm hardness and has a pH value of 4.5–6.5, is very corrosive. After pilot plant tests on treatment with lime, Na silicate, and Na hexametaphosphate and lime, and large scale tests with first two compounds, lime treatment adopted. About 5–6 ppm is required to increase pH to 7 or slightly higher. Avg. Pb content of delivered water reduced from 1.18 to 0.14 ppm. Approx. 19% more Cl, applied subsequent to lime, required to maintain residual Cl 0.2 ppm.—*R. E. Thompson*

The Importance of Silica in the Formation of Protective Coatings in Cast-Iron Pipes. CARLOS F. HICKETHIER. Rev. Obras Sanit. Nacion. (Arg.) **16**:144:2 ('52). To be noncorrosive toward Fe-C alloys a water must: [1] have a carbonate hardness greater than 36 ppm; [2] contain an excess of dissolved O_2 to depolarize and oxidize Fe^{++} formed by incipient corrosion of Fe; [3] have pH equal to or higher than the Langelier satn. pH. Freedom from pipe corrosion in the distr. system of Paso de los Libres, where the relatively soft waters are low in dissolved O, is attributed to the presence of 50 ppm of SiO_2 and to 25 ppm of NO_3. The latter serves as an oxidizer and depolarizer to produce Fe^{+++}, which, with the SiO_2, forms a protective coating.—*CA*

Use of Surface-Active Agents in Cooling-Tower Water Treatment. W. F. OXFORD JR. Oil Gas J., **50**: 52:176, 263 ('52). Formation of $CaCO_3$ scale and corrosion of metal parts in cooling towers of gas-compressor plants can be essentially elimd. by treating the water being circulated with 13 to 1000 ppm of a mixt. of high-mol. wt., substituted glyoxalidines (Kontol 116 or 120) and acylated amino alc. (SP-8). Neither material when used alone will provide protection equal to that obtained with the mixt. at comparable concns. These materials are also believed to be effective in controlling cooling-tower delignification. This treatment has been successfully used in 3 compressor plants, and was found not to be applicable in a fourth plant for reasons yet unknown. In one plant water-treating costs were reduced from $5.11 per day to $0.375 per day with this treatment. These compds. are believed to prevent scale and corrosion by forming a film on the metal surfaces in the system being treated. It is suggested that the synergistic effect obtained when these two materials are used together results from a pptn. of free amine, formed by interaction of SP-8 and OH^-, at or near cathodic areas; this interferes with the action of the cathode.—*CA*

Concentration Films: Their Role in Boiler Scale and Corrosion Problems. H. M. RIVERS. Combustion, **23**:10:57 ('52). When water is in contact with a metal surface at a higher temp. than that corresponding to its bp., tiny bubbles of steam are formed at the metal surface. As these grow, evapn. occurs around a ring where the bubbles join the metal. Impurities in the water thus evapd. tend to conc. in the ring. When satn. is reached with respect to some constituent in the water, pptn. results; the process continues, leaving a film of highly concd. brine or a crust of pptd. salts. If the boiler water contains dissolved matter, a concg. film is created under every steam bubble. The concn. of dissolved salts in this film tends to increase until the soln. bp. approximates that of the metal surface. Fresh boiler water flushes over the surface after each bubble becomes detached, tending to remove the concg. film. If film concns. build up more rapidly than they can be removed by rinsing, scale accumulation or other

(*Continued on page 64*)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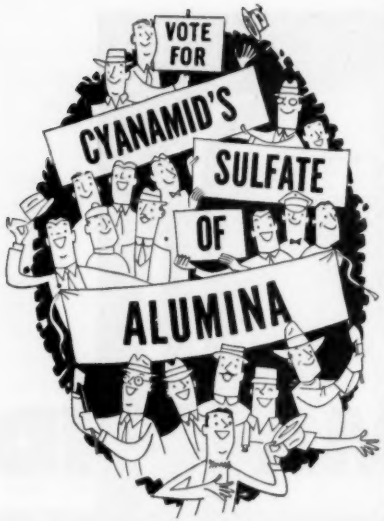

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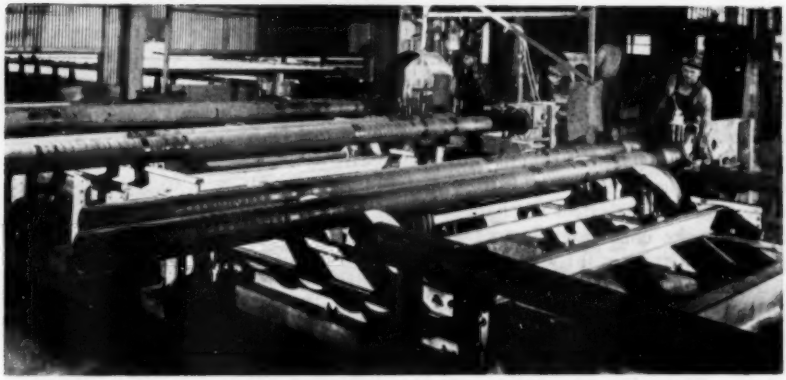
(*Continued from page 62*)

adverse effects may result. Such deposits can be avoided: [1] by reducing the heat input so that lower concns. will be obtained in the concg. films; [2] by increasing liquid velocity and turbulence to dissipate the concg. films; [3] by modifying the boiler-water compns. to exclude compds. which tend to crystallize or produce adherent residues; [4] by adding special chemicals to disperse suspended solids in the boiler water and render them less resistant to rinsing; and [5] by reducing the total amt. of dissolved and suspended matter in the boiler water. Caustic concns. in the films to as low as 5% NaOH may dissolve the protective oxide on steel tubes; the Fe reacts immediately with water to attempt to form a film. This process can go indefinitely, forming H. The latter may be one of the causes of the reduction of Cu ions to metallic Cu. Caustic embrittlement may also occur. A continuous layer of deposited material may reduce corrosion but cause failure owing to poor heat transfer and overheating. "Hideout" or disappearance of Na_3PO_4 in boilers operated at high ratings may be due to pptn. under such conditions, reappearing when the boiler is again operated at low ratings when the water makes better contact with the metal surface. Some boiler-water components may decompose in the concg. films; sulfite may decompose at hot spots to give H_2S and org. treating chemicals may sometimes decompose to carbonaceous residues which interfere with rinsing and promote even higher film concns. Higher amts. of Si in steam than would correspond to the boiler water temp. may be due to such local overheating. Under certain conditions complex silicate scales may be formed. Scale formation tends to intensify the formation of concg. films. When oil is present, scale and sludge tend to become more firmly bound, resisting rinsing.—*CA*

(*Continued on page 66*)



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(*Continued from page 64*)

Influence of Temperature on Corrosion Rates in Moving Conditions. F. WORMWELL & H. C. K. ISON. Chem. & Ind., **1951**:15:293. In continuation of studies on the corrosion of mild steel exposed to rapidly moving water or aqueous solns., investigations were made on the effect of changes in temp. on the corrosion of emeried or grit-blasted steel in 0.1*N* sodium chloride soln. An increase in temp. from 25 to 30 C increased the rate of corrosion of grit-blasted steel by approx. 100% and of emeried steel by approx. 50%. There is an approximately straight-line relation between the logarithm of the rate of corrosion and the reciprocal of the absolute temp.—*WPA*

Cathodic Protection at Imperial Dam. J. P. COLLOPY & W. D. FREEMAN. Eng. News-Rec., **146**:1:43 ('51). In order to control electrolytic corrosion of unprotected metal surfaces at Imperial Dam by the warm saline water of the Colorado R., a system of cathodic protection has been installed. Sacrificial anodes of scrap steel, aluminum alloy, and carbon are used. At present a current consumption of 1.36 ma per sq ft of metal gives adequate protection but may have to be increased when the protective coating of coal-tar enamel on the steel is destroyed.—*WPA*

Some Aspects of Corrosion Prevention in Practice. W. MONTGOMERY. Sheet Metal Inds., **27**:643 ('50). Measures currently used for control of corrosion of iron and steel structures are reviewed briefly. Three representative methods—barffing, vitreous enamelling, and galvanizing—are described in some detail, and their relative advantages are discussed.—*WPA*

Scattering of Light in Water Kept in Contact With Metals. A. GEORGE. Current Sci. (Ind.), **20**:201 ('51). Expts. were made to det. whether metals go into soln. when kept in contact with water by studying the scattering of light as a function of time. Gold had no appreciable effect on scattering, but with copper, silver, and brass the intensity of scattering increased rapidly during the first 5 hr and then more slowly till a steady value was reached within approx. 48 hr. Silver had the most marked effect and brass the least. The track of scattered light was blue and homogeneous indicating that the particles causing scattering were uniformly dispersed and in a fine colloidal form; the size of the particles increased gradually with time.—*WPA*

Some Methods of Protection Against Metallic Corrosion. T. A. EVANS. J. Inst. Prod. Engrs., **30**:2:62 ('51). Some methods used in the prevention of corrosion are described. Sodium chromate is an anodic inhibitor which may be used to prevent corrosion of iron, steel, zinc, aluminum, copper, brass, and lead. Calcium bicarbonate and salts of zinc and nickel can be used as cathodic inhibitors. To protect cooling systems of internal combustion engines, 1.5% of sodium benzoate and 0.1% of sodium nitrite can be added to solutions of glycerol or glycol.—*WPA*

Corrosion Problems in Processing. U. R. EVANS. Can. Chem. Processing, **36**:2:38 (Feb. '52). General discussion of corrosion by cooling water. Cheapest method of control that of utilizing $Ca(HCO_3)_2$ already present in most waters to form film of "rusty chalk." Is less protective at high temp., and ineffective for water contg. much NaCl. Film contains Fe as result of interaction of $CaCO_3$ and Fe salts. Haase states that a Ca–Fe double carbonate often present. O needed for film formation. Bacterial growths may screen certain points from O and

(*Continued on page 68*)

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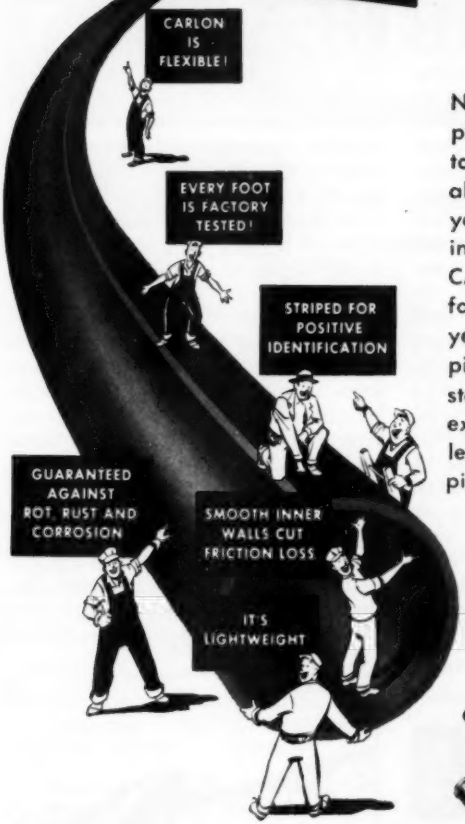
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(Continued from page 66)

prevent film formation. Sheathforming Fe bacteria (*Gallionella ferruginea*) help set up corrosion of differential aeration type. Relatively small anodic (screened) areas surrounded by larger cathodic areas to which O has ready access may result in intensified attack. Anaerobic conditions below growth of Fe bacteria favorable to sulfate-reducing bacteria, *Vibrio desulfuricans,* which attacks steel rapidly in absence of O. Polymetaphosphates, formerly regarded as anodic inhibitors, now considered cathodic inhibitors. Metaphosphate reacts with water (fairly rapidly at higher temps.) giving acid orthophosphate, NaH_2PO_4; latter anodic inhibitor and can intensify attack if not present in sufficient quantity. If dissolved substances absent, relatively small concn. Na_3PO_4 will render water noncorrosive. Here also, O needed. In presence of excess PO_4^{---}, if Cl^- and SO_4^{--} absent, Fe ions cannot exist and there appears to be no reason why film not continuous. Invisible protective film is gamma-ferric oxide, together with hydrated ferric phosphate. If Cl^- or SO_4^{--} present, phosphate must be increased; similarly with other anodic inhibitors, such as Na carbonate or silicate. No inhibitive action until sufficient phosphate added to completely remove Ca salts. Inhibitors which do not react with Ca salts include nitrites and chromates. Some nitrite consumed in preventing attack and ample concn. should be allowed. Action of nitrites and chromates may be essentially similar to that of O. For internal combustion engine cooling, Na benzoate, with or without $NaNO_2$, used.—*R. E. Thompson*

CHEMICAL ANALYSIS

The Colorimetric Determination of Aluminum in Water Using Ammonium Aurin Tricarboxylate. A. C. ROLFE, F. R. RUSSELL, & N. T. WILKINSON. J. Appl. Chem. (Br.), **1**:170 ('51). A method is described for the detn. of aluminum in water using ammonium aurin tricarboxylate at a pH value of 4.4. Reaction of iron is inhibited by addition of thioglycollic acid to form ferrous thioglycollate which is colorless at pH 4.4. The test is sensitive to 0.0003 mg of aluminum, and satisfactory results were obtained for amounts up to 0.02 mg. Anions and cations in the concns. normally present in water do not interfere; excessive amts. may cause interference. Hexametaphosphate and pyrophosphate interfere but the effect can be overcome by hydrolysing to *o*-phosphate. When sodium chloride is likely to be produced in the analysis of alkaline products, an aluminum calibration curve should be prepared using an amount of sodium chloride equal to that produced in the test sample. Preparation of pure reagents is described.—*PHEA*

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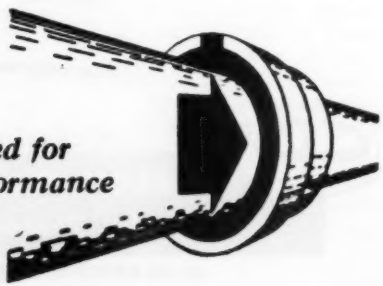

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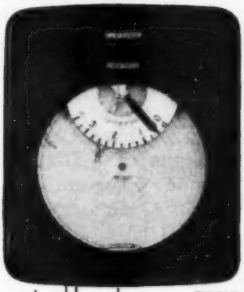

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Microanalysis of Aluminum and Iron. TAKASHI ASHIZAWA. Repts. Balneol. Lab. Okayama Univ. (Jap.), **1951**:5:76. For detg. small quantities of Fe and Al in natural waters, the following procedure is recommended. Evap. water contg. less than 5 mg of Fe and Al to 15 ml, and extract Fe as thiocyanate with amyl alc. Det. Al with aluminon and sep. from Fe with salicylic acid. When a large excess of Ca is present, remove Fe and Al as hydroxides. The interference of F can be elimd. by adding $Th(NO_3)_2$. After detg. Fe, traces of Cu, Zn, Ni, and Co were detd. by the dithizone-chromatographic method with the same amyl alc. extraction.—*CA*

Boron in Polish Water Supplies. I. OBUCHOWSKI & J. JUST. Gaz, Woda i Techn. Sanit. (Pol.), **26**:141 (May '52). In continuing study to det. microelements in public water supplies and their public health significance, 358 samples from 178 Polish water supplies were examd. for boron. Boron detd. colorimetrically using modified Hatcher-Wilcox method. Results of study tabulated and indicate that, in general, water supplies contain small amounts of B as follows: 85 samples showed no trace, 48 samples showed from 0.025 to 0.050 mg/l, 35 samples 0.075 to 0.150 mg/l, 3 samples 0.175 to 0.250 mg/l, 4 samples 0.300 mg/l, and 8 samples more than 0.300 mg/l. One rather interesting aspect advanced by the authors that those water supplies high in B are also relatively high in F and I. Most supplies are located in a corridor extending southward between Gdansk and Elblung. Four supplies listed with B contents ranging from 0.6 to 2 mg/l, showed I contents of 0.008 to 0.084 mg/l, and F contents of 1.2 to 3.2 mg/l.—*Conrad P. Straub*

Determination of Free Carbon Dioxide in Waters. A. HERCULANO DE CARVALHO. Rev. quim apl., **1**:99 ('50). A method is derived, employing the activity concept. of calcg. the concn. of free CO_2 in natural waters of pH < 8.4, knowing the ionic compn. of the soln., the pH (detd. with a glass electrode), and the alky. (detd. by titration with standard acid to methyl orange endpoint). Nomograms are given enabling the results to be obtained rapidly. Values near the actual values were obtained with a series of artificially prepd. waters of known compn. It was found that the direct detn. of free CO_2 by titration with aq. Na_2CO_3, with phenolphthalein, cresol red, or the like, gave low results unless care was taken to avoid losses of CO_2 during the titration.—*CA*

Determination of Free Chlorine in Water by Means of *o*-Dianisidine-Dihydrochloride Reagent. K. L. MCEWEN & G. A. GRANT. Can. J. Technol., **30**:66 ('52). Prep. the reagent by satg. a satd. soln. of *o*-dianisidine with dry HCl at 0 C. Filter, wash with acetone, dry, pulverize, and again wash with acetone. Use a 0.1% soln. for the analysis. Add 1 ml of this indicator soln. to 10 ml of the water to be tested. After 25 min transfer to an absorption cell with a 2-cm light path. Measure the color in a Beckman Spectrophotometer at a radiation of wave length 450 mμ.—*CA*

Fluoride Content of Water Supplies in the Province of Gdansk (Danzig). ZOFIA GESCHWIND & JANINA JURKIEWICZ. Gaz, Woda i Techn. Sanit. (Pol.), **26**:116 (Apr. '52). Survey of Polish water supplies reported in '49 showed most were low in F content except for those in Danzig Province. These water supplies studied more intensively and results reported. 367 samples from 26 public water sup-

(*Continued on page 72*)

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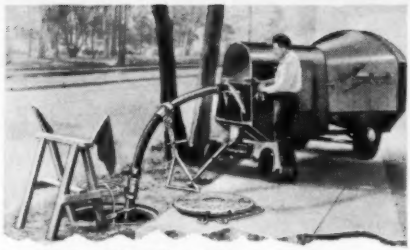

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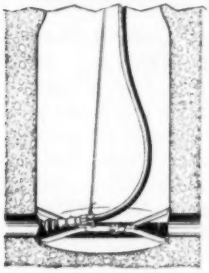

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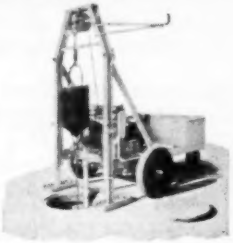

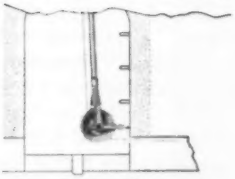

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(Continued from page 70)

plies (PWS) and 285 public wells (PW) analyzed for F. Found that F content in 49 samples taken from PWS and 256 from PW ranged from 0 to 0.5 mg/l F, in 3 PWS and 10 PW from 0.6 to 1.0 mg/l F, in 7 PWS and 20 PW from 1.1 to 2.0 mg/l F, and in 2 PWS and 20 PW F content exceeded 2 mg/l. Authors conclude that Province of Danzig offers good possibilities for studying advantages of water supplies contg. optimal F concns. as compared with areas within Province having F concns. above and below the optimum.—*Conrad P. Straub*

Determination of Ozone in the Drinking-Water Test. F. ZEHENDER. Mitt. Gebiete Lebensm. Hyg. (Swiss), **43**:144 ('52). The iodometric detn. of O_3 in H_2O is discussed.—*CA*

Determination of Low Water Hardness. D. A. SAVINOVSKIĬ, T. B. STYUNKEL, & E. M. YAKIMETS. Izvest. Vsesoyuz. Teplotekh. Inst. im. Feliksa Dzerzhinskogo (USSR), **21**: 2:26 ('52). The method employs back titration carried out at a pH of approx. 12.3. As buffer use a soln. contg. 40 g/l $Na_2B_4O_7 \cdot 10H_2O$ and 10 g/l NaOH. To a sample of analyzed water add a measured vol. of Trilon B, then add the buffer soln., Eriochrome Black T (indicator), mix thoroughly, and titrate with a 5% soln. of a Mg salt. The endpoint is indicated by transition from green-azure to blue-lilac. By this method hardnesses of 0.005–0.045 deg were detd. Mn, Cu, and Zn interfere.—*CA*

The Titrimetric Determination of Total Hardness and Lime Hardness of Water with Ethylenediaminetetraacetate. R. SIJDERIUS. Chem. Weekblad (Neth.), **48**:21:378 ('52). Effect of $KMnO_4$, free Cl_2, Cu, Fe, Cl^-, and CO_3^{--} was detd. by the Schwarzenbach hardness method. Using 0.6 ppm $KMnO_4$, color is bleached requiring addn. of hydroxylamine to the indicator; same with excessive free Cl_2; presence of 0.2 ppm Cu requires addn. of 2 ml 10% KCN. Fe changes color. High Fe concns. require dilution. No effect of NaCl. For detn. of total hardness, eriochrome as indicator and NH_4OH or Na_2CO_3 buffer can be used, provided immediate titration takes place. Det. of Ca hardness with murexide indicator allows 5 min delay in titration; when high hardness, dilution is preferable. Titration in Erlenmeyer flask is better than in porcelain dish. —*W. Rudolfs*

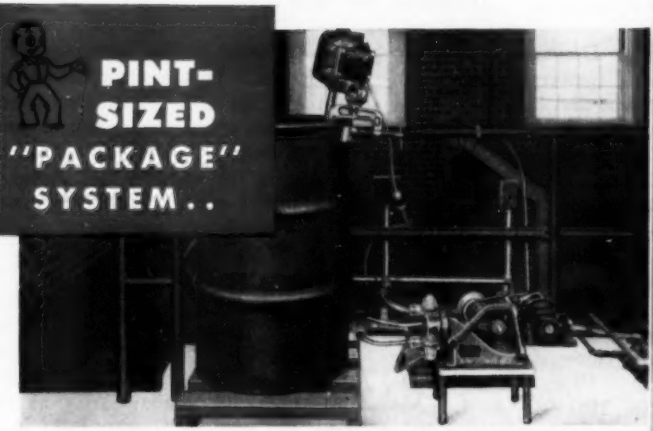
Test for Traces of Organic Matter in Water. A. I. MEDALIA. Anal. Chem., **23**:1318 ('51). The procedure consists of adding Fe^{++} and H_2O_2 to the sample. After mixing, the soln. is allowed to stand for 15 min, and the excess Fe^{++} is titrated with $Ce(SO_4)_2$ with ferroin indicator. The oxidation is based on the assumption that the reaction between Fe^{++} and H_2O_2 initiates a chain reaction in which the dissolved O reacts with the org. compds. with the formation of org. peroxides. The oxidation obtained is not as complete as that with dichromate.—*CA*

Some Applications of Ion Exchange to Water Analysis. JAMES W. McCOY. Anal. Chim. Acta (Fr.), **6**:259 ('52). A system for the sepn. of the various ions found in cooling waters is described based on the use of ion-exchange resins. These sepns. make possible the use of rapid colorimetric methods and save considerable time in the routine analysis of industrial waters. The prepn. of the resins is also described.—*CA*

BOILERS AND FEEDWATER

Conditioning Raw Water for Boiler Use. DAVID M. MYERS. Paper Ind.,

(Continued on page 74)



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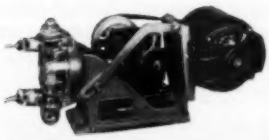
This little %Proportioneers% "package" handles the complete fluoridation job for a town* of 12,000 people. Feeding a constant strength slurry of sodium silico-fluoride into the pumped supply, the %Proportioneers% system assures economical, safe fluoridation with minimum attention and maintenance.

Simplicity is the keynote! The fluoride slurry is fed by %Proportioneers% Midget Heavy Duty Chlor-O-Feeder . . . a low cost unit that's both easy to install and easy to operate. The concentrated slurry is fed into a bypass where it is diluted, mixed, and conveyed to the main line which feeds the elevated storage tank. Because this is a positive displacement pump, over-fluoridation is a physical impossibility. In case of mechanical failure, no condition can cause fluoridation in excess of the norm specified by the state board of health.

This system involves simple electrical hook-ups . . . a cross-connection between chemical feeder and main water pump plus a time delay circuit which starts the recirculating pump and agitator three minutes ahead of the feeder motor.



%Proportioneers, Inc.% offers many "packaged" systems for high accuracy, low cost fluoridation. Write for Bulletins SAN-9 and SM 9363-2. %Proportioneers, Inc.%, 365 Harris Ave., Providence 1, Rhode Island.

*Name of town on request.

%PROPORTIONEERS INC.%

Representatives in principal cities of the United States, Canada, Mexico, and other foreign countries

(*Continued from page 72*)

33:1321 ('52). Descriptive. The economic balance between cost of feedwater treatment and heat recovery is stressed.—*CA*

With the Use of Approved Chemicals in Locomotive Feedwater for the Purpose of Reducing the Blowdown and Carrying Higher Solids in Boiler Water, What, if Any, Adverse and Detrimental Effects Are Experienced From These Increased Solids. F. E. GODWIN, H. M. SCHUDLICH, et al. Proc. Master Boiler Makers Assn., **1951**:94. As the newly developed foam depressants consist of polyalkylene glycols and long-chain amines and amides, it has been found possible to carry a much higher amt. of dissolved solids in operating locomotive boilers without loss of power caused by foaming and carryover. By maintaining the alky. in the boiler water at the proper percentage of the dissolved solids, usually between 20 and 30, no particular increase in corrosion should occur. Sufficient blowdowns are still required to prevent high accumulations of sludge and suspended matter from baking on the sheets, and entrance of oil into the boiler should be avoided or kept below 1% of the sludge.—*CA*

Preparation of Boiler Feedwater for Pressures up to Sixty Atmospheres, and of Cooling Water. ERICH SEYB. Stahl u. Eisen (Ger.), **72**:25 ('52). The various methods of treating the waters are reviewed and discussed.—*CA*

Electrocolloidal Boiler-Water Treatment. MURDOCH HILL. Proc. Ann. Congr. S. African Sugar Technol. Assn., **22**:49 ('48). An electrocolloidal system was installed in the make-up water-supply pipe to a boiler plant consisting of 3 boilers, each of 5400 sq ft heating surface, in which the avg. make-up water contained 22 g solids/gal. This electrocolloidal system was one in which an elec. charge is imparted to the water prior to entering the boiler. Very little change occurred in the quantity or quality of scale for 4 weeks, after which each succeeding brush seemed to produce less scale and an increased amt. of sludge relative to scale. When the boilers were subsequently opened there was still considerable scale, but less than previously and it was looser. During this time no chem. treatment was used. A similar unit was successfully used to remove scale in an automobile. Zn plates led to excessive corrosion in the boilers in a power station. Turpentine used in boilers in a blanket factory prevented elec. charges from forming and causing fires. Turpentine wiped on the shell of a boiler prevented corrosion.—*CA*

Filtration of Boiler Feedwater Using Diatomaceous Earth. THOMAS H. NORRIS. Pulp & Paper Mag. Can., **53**:3:187, 198 ('52). The operation of diatomaceous earth, pressure-leaf type of filter is discussed. For oil removal a precoat of 2 oz Sorbocel and ½ oz asbestos is used for each sq ft of filtering area.—*CA*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals, are listed below.

New Fluoride Removal Method Cuts Costs. Eng. News-Rec., **148**:24:40 (June 12, '52).

Viability of *Esch. coli* in Acid Mine Waters. J. MEHSEN JOSEPH & DONALD E. SHALY. Am. J. Pub. Health, **42**:795 (July '52).

Water-Softening Methods. I. Zeolites. PAUL BRINDIS. Power, **95**:11:84,210; 12:14 ('51).

NO NEED
to specify over-sized pipe . . .

NO WORRY
over low flow capacity . . .

NO NEED
to buy bigger and bigger pumps . . .

. . . when you protect pipe lines with BITUMASTIC® 70-B ENAMEL

Pipe lines don't "shrink" when the interior surfaces are coated with a spun lining of Bitumastic 70-B Enamel . . . because this durable enamel *prevents* rust, corrosion, incrustation and tuberculation.

When the inside diameter of your pipe line *stays* the same through the years, you select pipe solely on the basis of desired capacity. You don't waste money by specifying *over-sized* pipe in order to allow for future "shrinkage." When your pipe line's coefficient of flow *stays* high, you don't have to replace pumps with bigger ones that cost more to buy and operate.

Bitumastic 70-B Enamel is equally effective in protecting exterior surfaces of pipe lines. It prevents pitting and leakage caused by soil corrosion. Give your steel pipe lines *lasting* protection, inside and out, with Bitumastic 70-B Enamel. Write for details.

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KOPPERS COMPANY, INC., Tar Products Division, Dept. 1105T, Pittsburgh 19, Pa.

District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh, and Woodward, Alabama

(*Continued from page 18*)

The name game continues. The same fate which made Frank Drought chairman of the San Antonio, Tex., water conservation committee last month caught up with Ted Sprinkle, Indianapolis Water Co. operator, and flooded him out of his plant and into the nation's newspapers twice in one week. It accounts also for the fact that Terrell C. Drinkwater was elected president of the Los Angeles Chamber of Commerce. And certainly it was more than incidental in the choice of Wallace Waterfall as Secretary of the Acoustical Society of America. Need we point out that the Jordan, too, is a source of water supply as well as secretaries?

A new plastic pipe manufacturer enters the field with the decision of American Extruded Products Co., 1023 N. La Brea Ave., Los Angeles 38, Calif., to branch out from the making of garden hose to tubing of larger diameters. The pipe is marketed in sizes up to 6 in. under the trade name Amepco.

What price water? A penny a glass, according to *Restaurant Digest*, if you figure in the cost of labor, dishwashing, ice, glass, breakage, overhead, and, of course, the toothpick.

GREENSAND ZEOLITES

DURABLE — DEPENDABLE — LOW COST

Water Softening Zeolites

~ 3 Products to choose from ~

BASEX - - - - - - - a 3000 grain product
HI-BASEX - - - - - a 4000 grain product
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For new water softener plants, refills or replacements.
Thousands of water softeners with *greensand* zeolite, built over *20* years ago, are still in daily service, operating at full capacity and efficiency. Such outstanding performance is unmatched by any other zeolite.

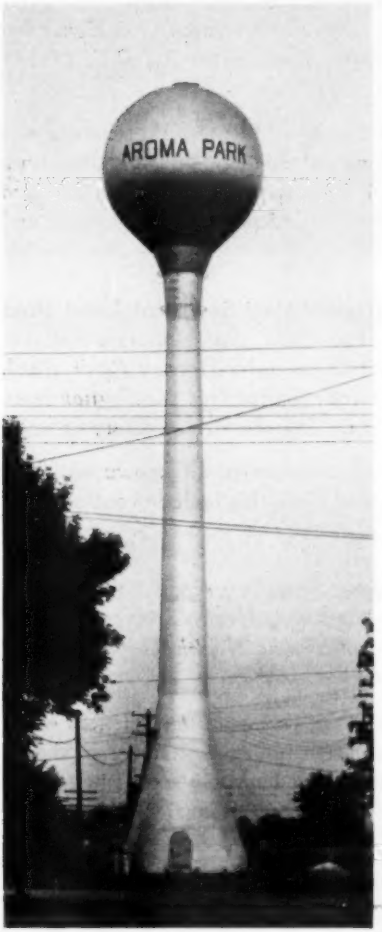
Write for details

Visit our booths at National Power Show, New York, Dec. 1-6, 1952.

HUNGERFORD & TERRY, INC.

CLAYTON 5, NEW JERSEY

Watersphere Installed at Aroma Park



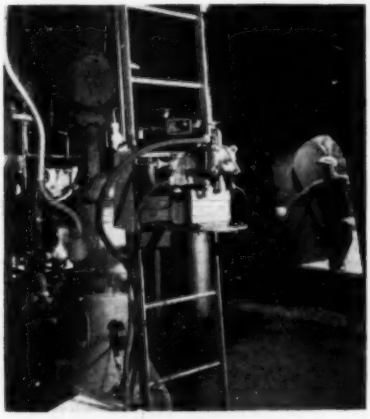
Above: 50,000-gal. Watersphere, 96-ft. to bottom, in Aroma Park, Ill., water distribution system.

Right: View inside base of Watersphere which serves as a pump house.

This 50,000-gal. Horton welded steel Watersphere was installed in the Village of Aroma Park, Ill., distribution system to provide dependable gravity water pressure for general service and fire protection.

The Watersphere was erected over the deep well which provides the water supply for the system. The 20-ft. diam. frustum of the structure contains the operating equipment for the system, including the deep well pump, chlorinator equipment, electric control board, water softening equipment, meter testing and water sampling facilities and a gas fired stove for heating. Inside of the cylindrical column at the top, gusset plates were provided for use in pulling the well shaft and bowls.

Write our nearest office for information on Horton Waterspheres.



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SAN FRANCISCO HOUSTON ATLANTA HAVANA WASHINGTON

The Reading Meter

(Continued from page 20)

List of Publications and Reports on Sedimentation. *Technical Letter Sed.-15e, Sedimentation Sec., Office of Research, Soil Conservation Service, U.S. Dept. of Agriculture, Washington 25, D.C. (1952) 22 pp.; paperbound; free*

This bulletin constitutes a bibliography of Dept. of Agriculture and Soil Conservation Service publications on sedimentation, together with similar reports published cooperatively with state and other agencies, and papers published by staff members in independent magazines and journals.

Inventory of Published and Unpublished Sediment Load Data in the United States. *Supplement 1946–1950. Sedimentation Bul. No. 4, Subcommittee on Sedimentation, Federal Inter-Agency River Basin Committee. (1952) 49 pp.; paperbound; limited free distribution from Geological Survey, Washington 25, D.C., and other cooperating agencies*

Supplementing Bul. No. 1, which inventoried all known sediment load measurements made before October 1946, this bulletin continues the record through September 1950.

North Atlantic Drainage Basins: *Summary report on water pollution. Water Pollution Series, No. 10; Public Health Service Pub. No. 111. Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 137 pp.; paperbound; free*

One-fifth of the country's population, living on one-thirtieth of its land, present a formidable stream pollution problem. Only 7 of the 30 millions who crowd the area are considered adequately served by sewage treatment, although all the states in the regions drained by these rivers

(Continued on page 89)

Filter Sand and Gravel

Well Washed and Carefully Graded to Any Specification.
Prompt Shipment in Bulk or in Bags of 100 lb. Each.

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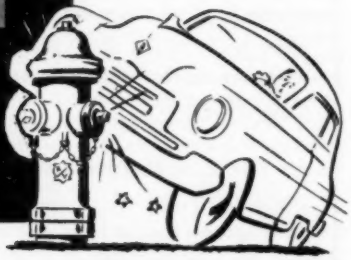
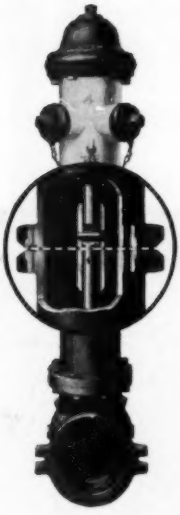
KENNEDY SAFETOP



The Hydrant that Cuts the Cost of Traffic Accidents



Wherever a fire hydrant faces the hazards of traffic . . . the community is safer, maintenance is lower, when it is a KENNEDY Safetop.

The whole secret is in the Safety Breakable Section (see enlarged inset on illustration). Notice the standpipe breaking ring. It has been so engineered that its strength is equal to that of the standpipe wall itself. This means that a KENNEDY Safetop Hydrant will stand up without breaking under any ordinary impact. But . . . the stresses are so distributed that when the breaking point is reached it breaks cleanly at the groove in the breaking ring.

The inexpensive stem coupling and breaking ring are the only parts to break . . . above ground where they are easily and quickly repaired. There's less damage to the car that hits it. Repair costs are a fraction of a below-ground break or of a fractured standpipe. The neighborhood does not risk curtailed fire protection for a protracted period.

ONE MAN in less than fifteen minutes, can permanently repair a KENNEDY Safetop Fire Hydrant broken in a traffic accident. A wrench, sledge hammer, screwdriver and a collision repair kit, consisting of a new Standpipe Breaking Ring, a new Stem Coupling, two pins and a gasket, are all he needs!

SEND FOR YOUR COPY OF BULLETIN 105

K V Est. 1877

THE **KENNEDY**
VALVE MFG. CO. • ELMIRA, N.Y.

VALVES • PIPE FITTINGS • FIRE HYDRANTS

The Reading Meter

(Continued from page 78)

—the Hudson, the Delaware, the Susquehanna, the Potomac, portions of the St. Lawrence, and various smaller streams—are taking energetic steps to meet the problem. This is the region of interstate compacts, with five active in various watersheds, as well as the International Joint Commission.

Lead in Modern Industry: *Manufacture, applications and properties of lead, lead alloys, and lead compounds. Lead Industries Assn., 420 Lexington Ave., New York 17, N.Y. (1952) 230 pp.; $1.50*

An all-purpose compilation, this book covers the mining, refining, fabricating, and the major industrial uses of lead. Of particular use in the water works field as a jointing material, an ingredient from which service pipe is made, and a component of metal-protective paints, the metal is discussed in each application, as well as in a host of others. A chapter on safe handling is also included.

Refinite serves the World
WITH WATER CONDITIONING EQUIPMENT & SERVICE
Refinite
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WATER REFINING EQUIPMENT
WRITE FOR FREE BULLETINS ON HOW REFINITE CAN SERVE YOU. ADDRESS: DEPARTMENT J-A

How's this for putting brains to work?

For more than 70 years, Cook Well Strainer Company, Inc., of Lawrenceburg, Indiana, has been making well strainers. For many of these years slotted seamless brass tubes, up to 12" in diameter, proved wholly adequate. But the insistent demand for more and more water called for deeper wells with larger diameters—and strainers to meet the new needs.

The basic features of the famously successful tube strainer—direct inlet; self-cleaning slot, larger inside than outside; one metal; strength; rigidity—would have to be duplicated in larger diameters.

Why not a wire-wound strainer with automatically made *mechanical* bonds? Indeed, why not? The illustrations on this page show the practical application of this ingenious idea. Cook Wire-Wound Well Strainers are now made in sizes up to 40" inside diameter—at high speeds, with slot widths readily variable, and lengths limited only by handling facilities.

Two ANACONDA Metals, Red Brass-24 and Everdur*-1010 Copper-Silicon Alloy, are outstanding for this application. Both machine readily, withstand upsetting, contribute strength and rigidity, and provide excellent resistance to corrosive ground waters. The American Brass Company, General Offices, Waterbury 20, Connecticut. 5292-B

*Reg. U. S. Pat. Off.

16" diameter, 35-foot-long Cook Well Strainer made of Everdur being installed at Fort Knox, Kentucky.

As the supporting skeleton of bars revolves in this winding machine, each bar is machine-notched ahead of the spirally wound wire (see circle illustration). This wire is a specially drawn AnacondA Shape of modified keystone cross-section. A circular form tool then displaces the metal on one side of the V-groove into the dovetail section of the wire, locking it securely.

the name to remember

ANACONDA®

COPPER, BRASS & BRONZE

Service Lines

A pH meter in a new, portable model has been announced by Photovolt Corp. in a circular known as Bul. 118. Available from the company at 95 Madison Ave., New York 16, N.Y., the leaflet describes the Model 125 meter which operates on three standard radio-type dry cells.

Old record storage on open steel shelves instead of closed boxes or transfer cases is made possible by equipment offered by Equipto, Aurora, Ill., and described in a catalog-circular that may be had for the asking. The steel units are available in various dimensions to fit different sizes of records, and shelves are adjustable. It is claimed that the open design not only speeds access, but permits narrower aisle space and higher stacking without loss of efficiency.

"A lot of things besides pumps" describes and entitles cartoonist Don Herold's impression of the manufacturing activities of Worthington Corp. The booklet is an attempt to enlarge the public's conception of the Worthington organization as a pump manufacturer and is a logical sequel to the recent change from the old Worthington Pump and Machinery Corp. name.

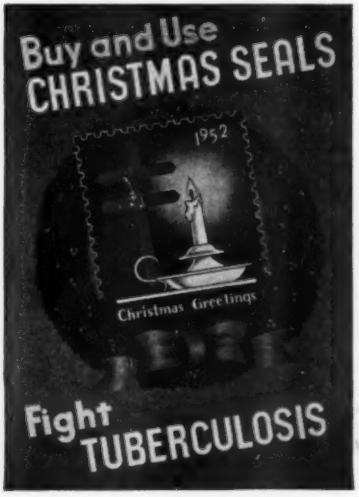
A descriptive catalog of the products and services offered by American Cyanimid Co., 30 Rockefeller Plaza, New York 20, N.Y., is available for the asking. The 36-page brochure describes the chemicals and compounds stocked and discusses their applications.

Power shovels and a truck crane offered by Gar Wood Industries, Inc., Findlay Div., Wayne, Mich., are described in an 8-page catalog available from the firm's Customer Service bureau.

"Over the rough spots" is the title of a booklet describing methods of patching or resurfacing floors and other surfaces. Copies are distributed by Stonhard Co., 1306 Spring Garden St., Philadelphia 23, Pa.

Pipe joint bolts made of "charcoal" cast iron are described in a folder distributed by H. Y. Carson Co., 1221 Pinson St., Birmingham, Ala. Bell-joint clamps are also described, and are suggested for stopping joint leakage on old pipelines.

A manual for water works engineers is what Stuart Corp. calls its 119-page book describing equipment and applications. Palmer surface wash equipment, Walking Beam flocculators, Leopold filter bottoms, Anthrafilt, and jar test machines are among the equipment described.



In 24 of America's large cities and scores of smaller towns, Rensselaer valve equipment has been used satisfactorily for 50 years or more.

Such records of performance and repeat orders cannot be accidental. They are due to the fact that all Rensselaer products are over-safe, both as to generous amounts of materials in the right places, and the incorporation of design features which insure reliable performance years after the valves are installed.

103

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GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

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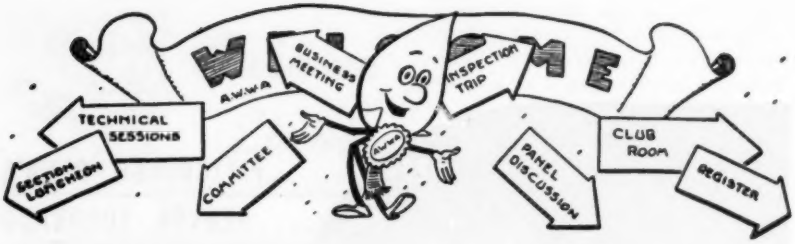
Sales representatives in principal cities



Section Meeting Reports

Minnesota Section: The 36th Annual Convention of the Minnesota Section—which includes members in the states of Minnesota, North Dakota, and South Dakota, and affiliated members of the Canadian Section—was held at Sioux Falls, S.D., on Sept. 9–12, 1952.

This is only the second time the meeting has been held outside of the state of Minnesota and the tenth time outside of the Twin Cities, St. Paul and Minneapolis. While there was in the beginning some doubt as to the success of a meeting so far from the metropolitan areas, the results more than justified the hopes of the optimistic.

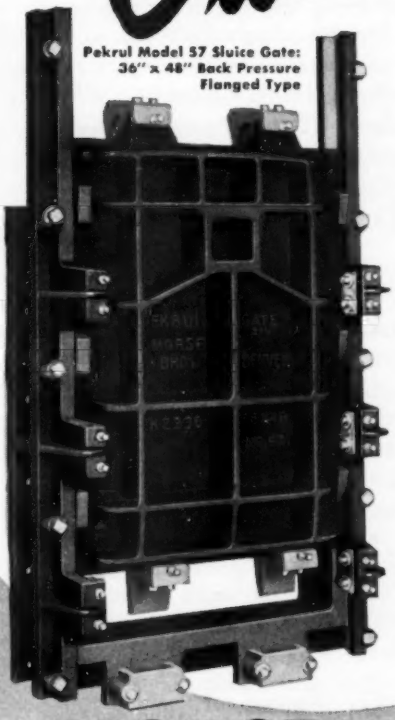
Attendance was above the average. Registration began the afternoon of Tuesday, Sept. 9, and was followed by a complimentary smoker, given by the city of Sioux Falls. The convention was officially opened the following morning with a most hearty welcome from Mayor Henry B. Saure. Wednesday, Thursday, and Friday mornings were devoted to a well rounded program of papers, which was very well received. The principal talks given were: "Ground Water Geology of South Dakota" by Bruno Petsch, assistant state geologist of South Dakota; "Pumps and Pump Efficiencies" by Arnold M. Steffes of Toltz, King & Day, St. Paul, Minn.; "Relation of Water Works Characteristics to Insurance Rates" by W. C. Freitag, engineer, Fire Underwriters Inspection Bureau, Minneapolis, Minn.; "Steel Storage Tank Maintenance" by E. L. Lium, acting dean, College of Engineering, Univ. of North Dakota; "Revaluation of Rate Structures" by Samuel Greeley of Greeley & Hansen, Chicago; and a panel discussion on "Fluoridation Practices" led by O. J. Muegge, state sanitary engineer of Wisconsin.

A paper on the Sioux Falls Water Treatment Plant by Commissioner John N. Browning and City Engineer R. E. Bragstad, an inspection trip, a luncheon given by the city of Sioux Falls, and the Annual Banquet were all added and attractive features.

The section was also honored by the attendance and speaking appearance of M. B. Cunningham, national vice-president.

(*Continued on page 86*)

Pekrul Gates



Pekrul Model 57 Sluice Gate: 36" x 48" Back Pressure Flanged Type

PEKRUL GATES are engineered to meet the most rigid requirements for:

- Flood Control
- Levees
- Irrigation
- Water Works
- Dams
- Sewage Disposal
- Reservoirs
- Pumping Plants
- Oil Refineries
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- Rearing Ponds
- Recreation Pools
- Cooling Towers
- Steel Mills

PEKRUL GATE DIVISION

MORSE BROS. MACHINERY
DENVER, COLORADO

Write for Catalog 49

(*Continued from page 84*)

A. C. Janzig, senior chemist in the Minneapolis Water Dept., was voted to receive the Fuller Award, and Fred Kriesel of Ortonville, Minn., was given the Ronald M. Finch Award.

N. S. Bubbis of Winnipeg, Man., was elected chairman for the coming year; George J. Schroepfer, Univ. of Minnesota, vice-chairman; and H. H. Behlmer, superintendent of Water Works, Fargo, N.D., trustee.

LEONARD N. THOMPSON
Secretary-Treasurer

Ohio Section: The Ohio Section officially opened its 14th annual meeting on the evening of Sept. 17, 1952, at the Netherland Plaza Hotel, Cincinnati, with advance registration for the following two days. Approximately 75 were registered during the advance period, and the total registration was 245, not including the 52 ladies registering for the conference.

Thursday morning the program was begun by a general discussion and audience participation. The presiding officer was C. E. Beatty of Middletown, and the panel was composed of Homer Knox, principal assistant sanitary engineer, Dept. of Health, Columbus; W. R. LaDue of Akron; W. Sahnd, superintendent of Water Distribution, Cincinnati; D. C. Laurence, superintendent of the Commercial Div., Water Works, Cincinnati; A. A. Ulrich, vice-president and manager, Massillon Div., Ohio Water Service Co., Massillon; and L. C. Huffman, superintendent, Dept. of Water and Sewerage, Dayton.

Following the panel discussion, Mayor Carl Rich of Cincinnati gave a hearty welcome to the water works men.

Charles H. Capen, AWWA President, concluded the first session with timely remarks on "The AWWA and You."

An inspection trip was planned in the afternoon to visit the Cincinnati Tennyson and California Stations. A large group was present at each plant. The description of the new filtering station was given by Ed Farmer, consultant of Black & Veatch.

The entertainment for the conference started with a reception given by the Water and Sewage Works Manufacturers Assn., with R. R. Weber of Cincinnati officiating, and was followed by the annual banquet. President Capen presented Life Membership certificates to Philip Burgess, J. S. Gettrust, Harold W. Streeter, and F. H. Waring. He also presented the Wendell R. LaDue Citation to the Republic Steel Corp. of Cleveland and W. W. Towne of Cincinnati. This section award is presented to members having a continuous service record of 20 years. Announcement was made of the George W. Fuller Award nomination of Earl L. Coleman of the Worthington-Gamon Meter Div., Ashland, "in recognition of his continued efforts and outstanding achievements in AWWA membership, his years of service as chairman of the membership committee and constant interest in

(*Continued on page 88*)

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ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge

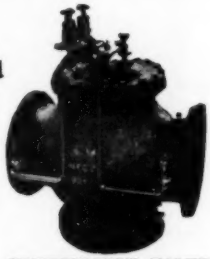
SURGE-RELIEF VALVE

REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow

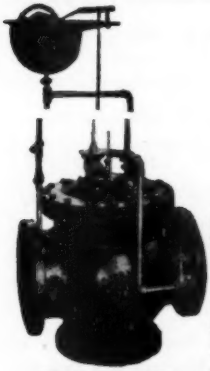
Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls



COMBINATION VALVE

Combination automatic control both directions through the valve.



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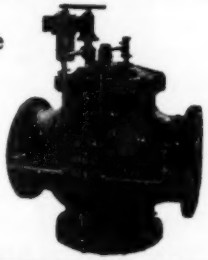
Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Electric remote control—solenoid or motor can be furnished



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Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N. Y.

(Continued from page 86)

the AWWA." Judge James Garfield Stewart of the Supreme Court of Ohio was the speaker of the evening. He charged the group to exercise their rights and use their abilities in voting to keep these United States a free country.

The sessions Friday morning were divided into two groups—management and purification. George VanDorp of Toledo presided over the purification session, with papers presented on "Disposal of Treatment Plant Wastes" by H. H. Mace, consulting engineer of Cincinnati; "High Capacity Zeolite for Water Softening" by J. W. Strub, Columbia Southern Alkali Co., Barberton; "Maintenance of Wells" by E. W. Bennison, Edward E. Johnson, Inc., St. Paul, Minn.; "Treatment Plant Operation and Maintenance" by J. A. Marsh, superintendent, Nottingham Plant, Cleveland.

C. E. Beatty of Middletown presided over the management session. Two movies were shown: "Made to Measure," by courtesy of the Rockwell Mfg. Co., and "Manufacture of Cast Iron Pipe," by the courtesy of the Cast Iron Pipe Research Assn. L. W. Bausher, assistant engineer of water works at Akron, presented a paper on "Akron Experience in Sizing and Maintaining Fire Protection, Industrial, and Commercial Services and Meters." R. H. Fuller, consultant of Burgess & Niple, Columbus, gave a paper on "Financing Utility Changes Occasioned by the Ohio Highway Construction Program."

At the Friday noon luncheon, W. R. Kellogg, city manager of Cincinnati, was introduced by Carl Eberling, superintendent of the Cincinnati water works. A business meeting followed, and the new officers elected were: C. E. Beatty, chairman; E. F. Leist, vice-chairman; M. E. Druley, secretary-treasurer; and M. W. Tatlock, trustee.

Mrs. C. E. Eberling was chairman of the Ladies Arrangement Committee and the program planned for the 52 ladies in attendance included a tour of the Taft Museum and Eden Park Conservatory on Thursday. Friday a tour was made of the Terrace Plaza Hotel, Cincinnati's newest hostelry. Luncheon was served in the Skyline Restaurant in the hotel.

M. E. Druley
Secretary-Treasurer

Kentucky-Tennessee: The joint meeting of the AWWA Kentucky-Tennessee Section with the Kentucky-Tennessee Industrial Wastes and Sewage Works Assn. was held September 15–17, 1952, at the Andrew Johnson Hotel, Knoxville, Tenn. The registration total of 252 was the largest in the history of the Associations.

The joint technical session was opened Monday morning with an address of welcome from Mayor George Dempster of Knoxville, and the response was given by John F. Connerton, superintendent of pumping stations for the Louisville (Ky.) Water Co. AWWA President Charles

(Continued on page 90)

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MEETS A.W.W.A. SPECIFICATIONS

ARMCO

(Continued from page 88)

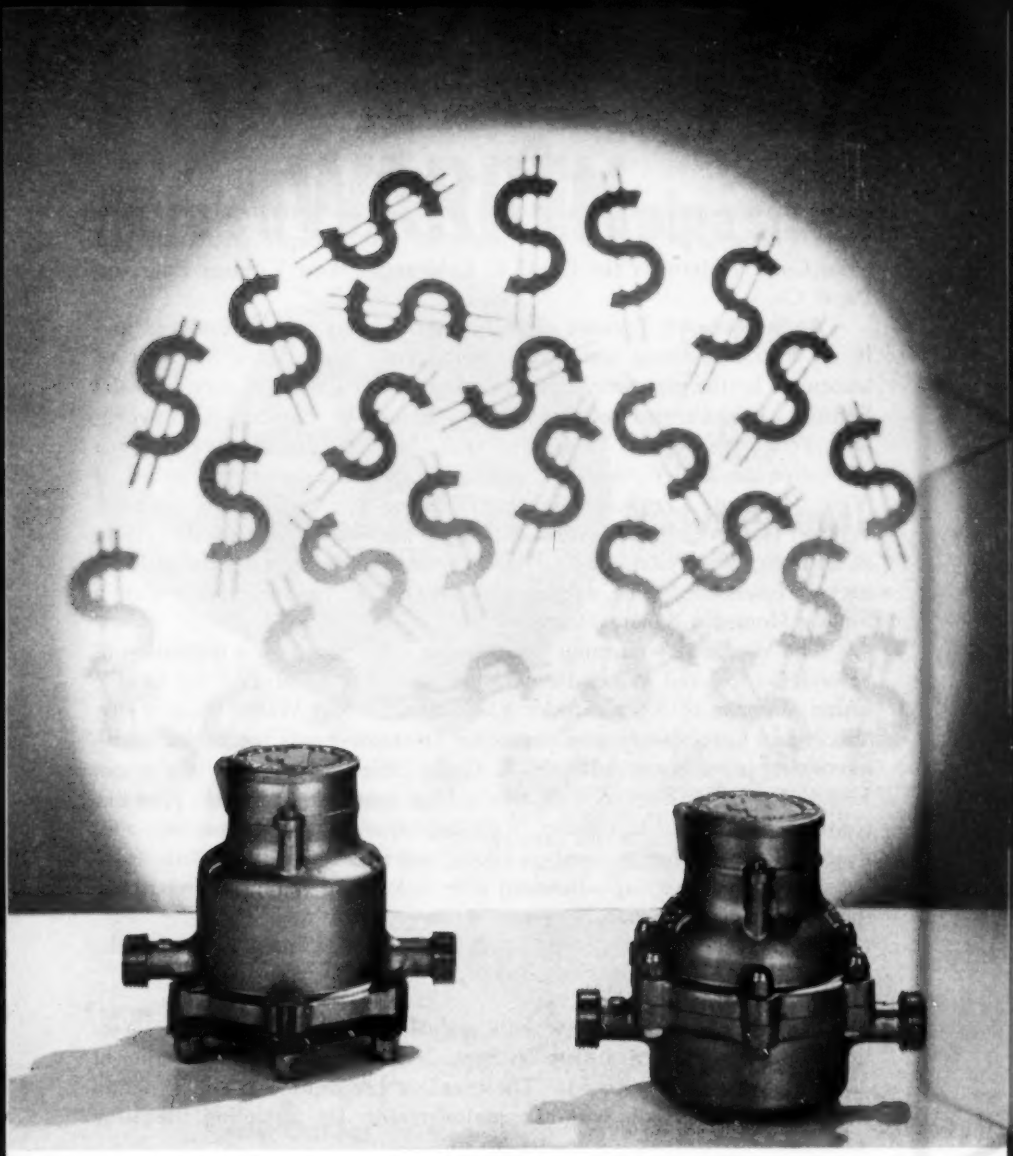
H. Capen addressed the group and discussed current problems facing the water works industry with particular emphasis on the problem of water main relocation necessitated by new highways. Executive Secretary W. H. Wisely of the Federation of Sewage and Industrial Wastes Associations spoke on cooperative means of meeting and solving municipal and industrial problems. A business meeting closed the morning session.

The afternoon session got under way with an address on "The Need for Engineers" by N. W. Dougherty, dean of the College of Engineering, Univ. of Tennessee. "Preparing a City's Utilities for New Industry" was the subject of a paper delivered by Mayor John R. Long of Springfield, Tenn. Mayor Long outlined a well planned program followed by his city in providing utilities services which will meet present and future needs as well as attract new industries. Lorin B. Allen, consulting engineer of Memphis, spoke on "Water and Sewer Service to Suburban Areas." A discussion of this urgent problem was led by Howard Hopkin, manager of the Jefferson County (Ky.) Sanitation Dist. No. 1, and numerous methods for financing and operating these suburban services were explained by members participating.

The Tuesday separate session was opened by a discussion of "Short-Coupled Turbine Pumps for Station Installations" by A. O. Fabrin, Layne & Bowler Pump Co., Memphis. William J. Dahlgren, Tennessee Inspection Bureau, in a paper entitled "Fire Protection Requirements," outlined the points covered in the rating system by which fire insurance rates are determined for municipalities. A color film on "The Manufacture of Cast Iron Pressure Pipe" illustrated the latest methods used in manufacture and testing. R. M. Richardson, U.S. Geological Survey, Knoxville, discussed "Ground Water Resources of East Tennessee" and indicated the geological formations which were most likely to supply adequate quantities of water for municipal use. The morning session was closed by a discussion of "Current Water Works Headaches" by E. D. Hawkins, Knoxville Utility Board.

"Legal Problems Confronting Water Works Management" was the subject of a very interesting and informative paper by John H. Murdoch Jr., American Water Works Service Co., Philadelphia. In the absence of V. A. Appleyard of NPA's Water Resources Div., Washington, D.C., his paper entitled "NPA Controls" was read by F. W. Kittrell. A panel discussion on "Fluoridation of Public Water Supplies" was presented by C. M. McCord, director, Water Div., Memphis; J. Wiley Finney, Jr., Tennessee Dept. of Public Health; and B. E. Payne, Louisville Water Co. McCord discussed "How Pressure Is Brought on Water Works Management" and outlined the promotional and educational program which has been conducted by the dental profession in Memphis. Finney discussed "Methods and Safeguards in Applying Fluorides," and Payne gave the

(Continued on page 92)



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(*Continued from page 90*)

customer reactions experienced during the fluoridation treatment in Louisville. The separate session was concluded with a paper on "Taste and Odor Control Methods" by David C. Colebaugh, West Virginia Pulp and Paper Co.

At the banquet Tuesday night the new officers were introduced and R. P. Farrell, retiring secretary-treasurer, was presented a fine pair of binoculars by the members in recognition of his ten years of service to the Section. It was announced that J. Wiley Finney Jr., Sanitary Engineering Div., Tennessee Dept. of Public Health, has been selected by the committee to receive the Fuller Award. President Capen announced the award of "Life Member" Certificates to the following members of the Section: William H. Lovejoy, Louisville; William J. McGonigale, Louisville; Alvin R. Murphy, Knoxville; A. F. Porzelius, Chattanooga; and Frederick H. Stover, Louisville. The evening's entertainment was concluded with a Smoky Mountain Square Dance.

The Wednesday morning joint session was opened by a discussion of "Flood Control and Water Resources Program in Kentucky" by Orville Chinn, director of the Kentucky Flood Control and Water Usages Div. "Short and Correspondence Courses for Operators" was the subject of an interesting paper presented by H. K. Gidley, chief engineer, West Virginia Health Dept. A discussion of this subject was led by G. R. Watkins, consulting engineer, Lexington, Ky., and considerable interest was evidenced by the number of members taking part in the discussion.

The annual meeting adjourned after hearing of committee reports in the open business session.

J. Wiley Finney Jr.
Secretary-Treasurer

Missouri Section: The seventh annual meeting of the Missouri Section was held in Jefferson City on Sept. 21–23. The total registration of 225 set an attendance record. The excellent preparation of the Program Committee undoubtedly was the major reason for attracting the large attendance.

The program this year departed somewhat from the usual form in that the water works program was divided into two divisions, termed the Water Management Division and the Water Plant Operation Division. The sewage works operators held their meeting at the same time, which meant there were three programs in session simultaneously. Breaking the water works program into two groups afforded an opportunity to compile a program pertaining to advanced water works practices and also a program appealing to the small plant operator dealing with practical every-day works problems.

Outstanding among the papers on the program were the discussions entitled "A Safety Program for the Water Utility" and "Recent Develop-

(*Continued on page 94*)

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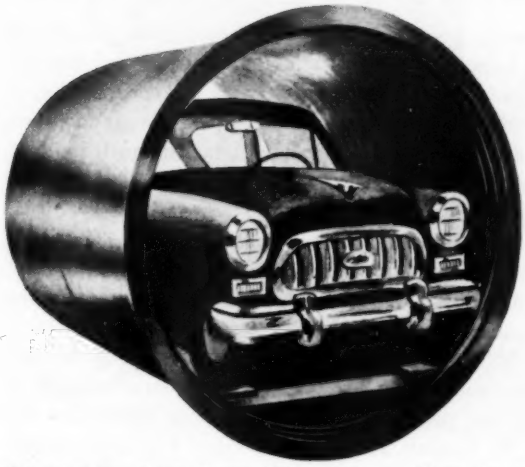

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(Continued from page 92)

ments in Municipal Financing," and the panel discussion on fluoridation. The introduction of the saftey program for water utilities attracted much attention.

New legislation recently passed in Missouri provides for combining revenues raised by bond issues for the construction of water and sewage. Under the new laws revenue bonds may be issued for the construction of sewage as well as water works, and a charge made for the sewage facilities.

As usual, the panel discussion on fluoridation attracted much interest, and the method of presentation was particularly well received. Opposing opinions on the practice were supported by the speakers.

Other highlights of the technical program were papers on "Chlorination Principles and Practices" by Harry A. Faber, "Innovations in Water Purification Plant Design" by E. H. Aldrich, and an explanation of the McIlroy flow analyzer presented by Glen Hands.

A buffet dinner was held on Monday evening and the annual banquet on Tuesday evening. Raymond J. Faust represented the national office of AWWA on this occasion and presented Life Membership certificates to: Elmer T. Archer, Jasper W. Everett, Ellsworth L. Filby, Charles S. Foreman, August V. Graf, Charles A. Haskins, Charles E. Jutz, Albert P. Learned, Robert E. McDonnell, Arthur L. Mullergren, and Edward E. Wolfe. Roger C. Higgins of Hannibal was selected as recipient of the Fuller Award for 1952.

WARREN A. KRAMER
Secretary-Treasurer

Rocky Mountain Section: The Annual Fall Meeting of the Rocky Mountain Section was held in Cheyenne, Wyo., September 16–17, 1952, at the Frontier Hotel. The total registration was 122.

Tuesday morning, September 16th, was devoted mostly to registration. Chairman Sherard introduced Everett T. Copenhaver, state auditor, who officially welcomed the delegates. Chairman Sherard then introduced Vice-President M. B. Cunningham of AWWA, who spoke on "Planning With AWWA in 1952."

At the Tuesday afternoon session, presided over by Chairman Sherard, the first paper was "State Health Department Policies for Water Supplies," presented by F. D. Yoder, director of the Wyoming Health Dept., and discussed by William N. Gahr, director of the Sanitary and Sanitation Div. of the Colorado Board of Health. "The Water System Problems of a City Manager" was presented by Ray Case, city manager of Greeley, Colo. The last paper of the afternoon session was presented by G. Mees, engineer for the Mountain States Inspection Bureau, Denver, Colo., who spoke on the "Factors That Determine the Basic Fire Insurance Rates."

(Continued on page 96)

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(*Continued from page 94*)

The Wednesday morning session was presided over by Chairman Sherard. The first paper of the morning was presented by Earl Mosley, manager of the Board of Water Commissioners, Denver, Colo., who spoke on "Water Conservation Through Metering and Effects on Revenue." Glenn Saunders, assistant city and county attorney for the Water Dept. in Denver, Colo., followed with a talk on "State vs. Federal Control on Water Diversion." A motion picture in color entitled "Deep Water," courtesy of the Layne & Bowler Corp., Memphis, Tenn., concluded the morning session.

A business luncheon was held in the Frontier Hotel Tuesday noon. Wednesday afternoon sessions were presided over by Carl Bennett, the chairman-elect. The following papers were presented: "Contamination of Water Supplies by Radioactive Materials," by William N. Gahr of the Colorado Health Dept.; "Theory of Coagulation on an Elementary Basis," by assistant professor R. E. Leffel of the Civil Engineering Dept., Colorado Univ., Boulder; "Filtration," by O. J. Ripple, consulting engineer, Denver; and "Fluoridation of Municipal Water Supplies," by R. P. Moffitt, senior sanitary engineer, Public Health Service, Denver. A round table discussion of problems concluded the afternoon program; at this time, Secretary Turre brought to the attention of the group the matter of amending the present law granting federal aid to railroads for changing their tracks to accommodate public highways. He advised those listening to advise the secretary of AWWA about the cost of water line changes necessitated by new highway construction. Mr. Turre remarked that it has cost the Denver Water Dept. approximately $140,000 to change water mains affected by the Valley Highway System in Denver.

The Annual Banquet was held at the "120 Club" on Wednesday evening. John L. Loomis of the Cheyenne Water Board acted as Toastmaster; Professor Leffel was the guest speaker. The Fuller awardee, A. D. Mars Jr. of Denver, Colorado, was introduced by Vice-President M. B. Cunningham, who read the citation giving the basis upon which the recommendation was made. The Chairman's Gold Lapel Pin was presented to the outgoing chairman, Ray Sherard, by the chairman-elect, Carl Bennett. A pantomime floor show followed the entertainment offered by U.S. Air Force singers and performers, and music for dancing concluded the evening. The ladies' entertainment consisted of a luncheon and a tour of the city of Cheyenne. A delicious antelope dinner, courtesy of the employees of the Water Dept., was held on Tuesday evening at the "Foot Printer's Club." The antelopes served were shot by employees of the Water Dept. near Rawlins, Wyo. After the dinner, music was provided for dancing. The city of Cheyenne extended many courtesies to the visiting delegates.

GEORGE J. TURRE
Secretary-Treasurer

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Coming Meetings

AWWA SECTIONS

November 5–7—Virginia Section at Chamberlin Hotel, Old Point Comfort. Secretary, W. H. Shewbridge, Regional Engr., State Dept. of Health, 708 State Office Bldg., Richmond, Va.

November 10–12—North Carolina Section at Skyland Hotel, Hendersonville. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh, N.C.

November 16–19—Joint meeting of Alabama-Mississippi and Florida Sections of AWWA and Florida Sewage & Industrial Waste Assn., at San Carlos Hotel, Pensacola. Secretary, Alabama-Mississippi Section, Chas. W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala. Secretary, Florida Section, Marvin R. Boyce, Boyce Co., 504 Pennsylvania Ave., Clearwater, Fla.

December 4–6—Cuban Section in Havana. Secretary, Laurence H. Daniel, Pres., Laurence H. Daniel, Inc., Baratillo 9, Havana, Cuba.

January 20, 1953—New York Section Winter Luncheon Meeting, at Park Sheraton Hotel, New York, N.Y. Secretary, R. K. Blanchard, Rm. 1922, 50 W. 50 St., New York 20, N.Y.

February 11–13—Indiana Section at Lincoln Hotel, Indianapolis. Secretary, G. G. Fassnacht, State Dept. of Health, 1330 W. Michigan St., Indianapolis 7, Ind.

OTHER ORGANIZATIONS

November 16–19—Florida Sewage & Industrial Wastes Assn. (Joint meeting; see AWWA Alabama-Mississippi and Florida Sections.)

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(See Prof. Services, pp. 25–29)

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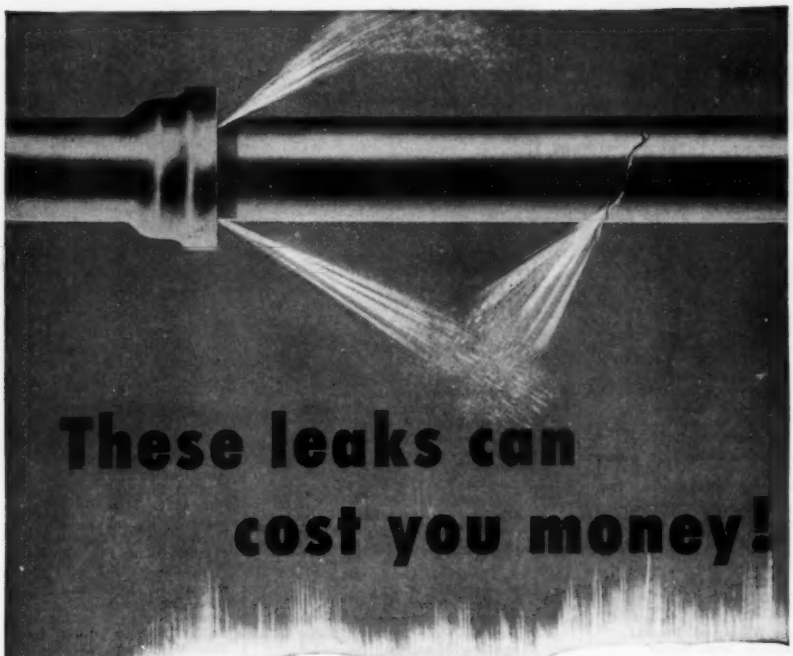

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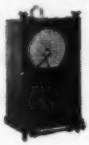

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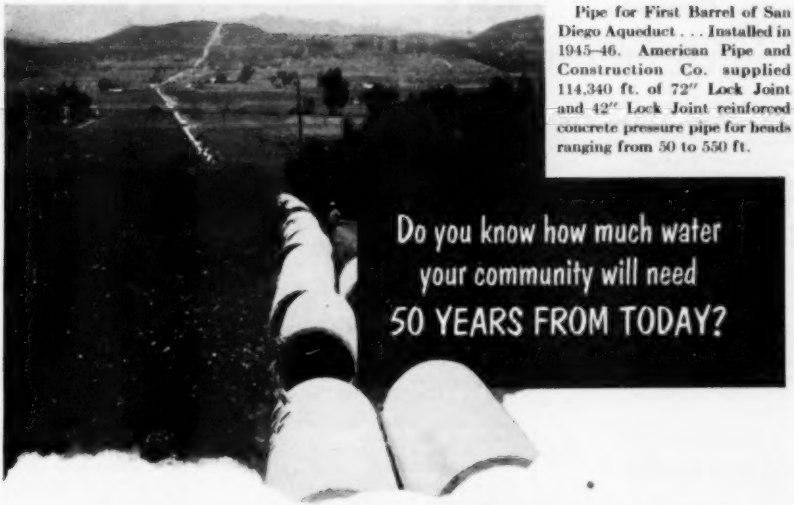

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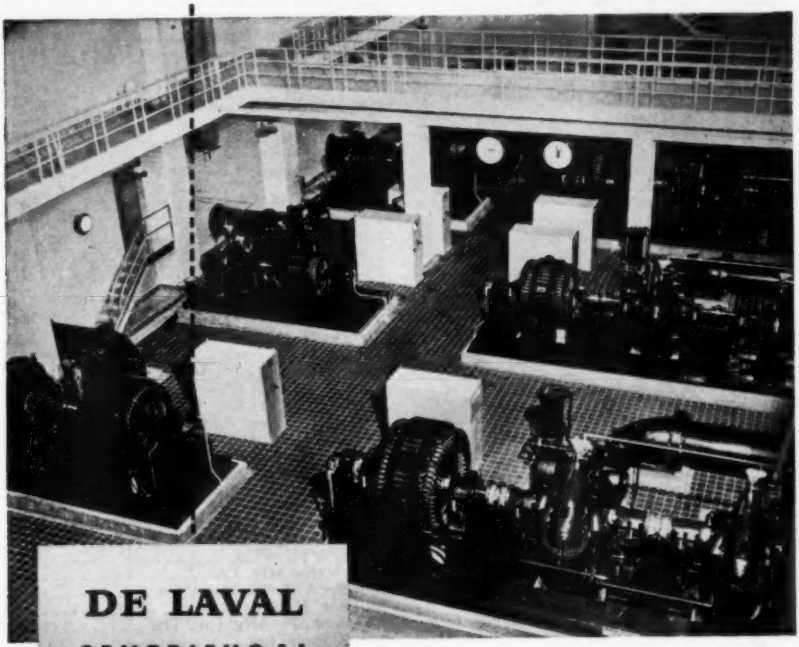

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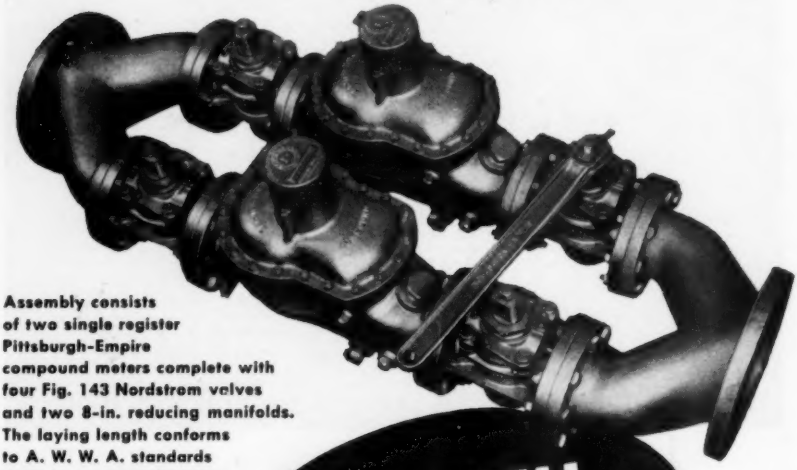

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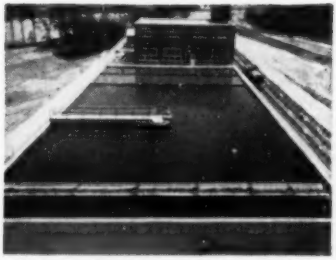

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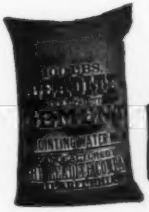

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